Before The
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Authorizing Permissive Use of the "Next Generation" Broadcast Television Standard	)	GN Docket No. 16-142
	)	
	)	

To: The Commission

Comments of the Merrill Weiss Group, LLC

Summary

In response to a Petition for Rulemaking filed jointly by four significant industry organizations[1] (the "Petition"), the Federal Communications Commission adopted the captioned Notice of Proposed Rulemaking to authorize television broadcasters to use the "Next Generation" broadcast television (Next Gen TV) transmission standard associated with recent work of the Advanced Television Systems Committee ("ATSC 3.0"). As a participant in and contributor to development of nearly all of the approximately twenty documents that comprise the ATSC 3.0 standards suite, the Merrill Weiss Group LLC ("MWG") commends the Commission for taking this action and offers the following comments in response to certain of the subjects and questions raised in the NPRM.

Specifically, in the NPRM, the Commission discusses Single Frequency Networks (SFNs) and Distributed Transmission Systems (DTSs) (which are essentially equivalent to one another[2]), notes certain comments received on those subjects in response to the Petition, and reaches some tentative conclusions with respect that subject area and the rules that should apply to it. These comments address certain aspects of those topics that seem appropriate given our knowledge and experience.

[1] Joint Petition for Rulemaking of America's Public Television Stations, the AWARN Alliance, the Consumer Technology Association, and the National Association of Broadcasters, GN Docket No. 16-142 (filed April 13, 2016).
[2] DTS is a somewhat more encompassing name for Single Frequency Network (SFN) technology.

In summary, these comments generally support the Commission's approach to application of the existing DTS rules to SFNs operating in conformance with the ATSC 3.0 standard suite. They do, however, point out certain deficiencies in the existing rules that should be corrected if full benefit is to be taken of the improvements that ATSC 3.0 technology enables, and they offer relatively straightforward adjustments to existing methods to address the deficiencies. They discuss the question raised by one commenter on the Petition as to which documents from the ATSC 3.0 standards suite need to be referenced in the Commission's rules to enable use of SFNs. They also discuss the mathematical method used to aggregate the signal levels from multiple transmitters in an SFN of one station when analyzing interference to another station.

Introduction

For background, MWG or its principal has been involved in the development of the technology of SFNs and in their analysis since 1991. First comments to the Commission on the potential for use of SFNs by television broadcasters were filed by MWG's principal in 1992 with respect to the work of the Advisory Committee on Advanced Television Service (ACATS) Implementation Subcommittee Working Party 2 on Transition Scenarios. MWG filed comments in the FCC First[3] and Second[4] DTV Periodic Reviews, supported by numerous broadcasters. In the Second DTV Periodic Review NPRM, the Commission asked for inputs on whether to proceed with adoption of rules to permit routine licensing of Distributed Transmission System (DTS) technology, and in the related Report and Order,[5] the Commission approved in principal the use of DTS technologies and established interim guidelines for permitting such operations. In 2005, the FCC adopted a Clarification Order and NPRM[6] to clarify the interim procedures and to move toward permanent rules for routine licensing of stations using DTS technology. The DTS rules were adopted by the Commission in the DTS Report and Order[7] in 2008.

[3] "In the Matter of Review of the Commission's Rules and Practices Affecting the Conversion to Digital Television," MM Docket No. 00-39, Comments of Merrill Weiss Group, May 17, 2000.

[4] "In the Matter of Second Periodic Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television," MB Docket No. 03-15, Comments of Merrill Weiss Group, LLC, April 21, 2003.

[5] *Second Periodic Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television*, 19 FCC Rcd 18279, 18283, 18355-57, ¶¶ 9, 174-78 (2004)

[6] Clarification Order and Notice of Proposed Rulemaking "In the Matter of Digital Television Distributed Transmission System Technologies," MB Docket 05-312, adopted November 3, 2005.

[7] Report and Order "In the Matter of Digital Television Distributed Transmission System Technologies," MB Docket 05-312, adopted November 3, 2008.

In the time between adoption of the DTS rules and the application filing freeze preceding the broadcast spectrum Incentive Auction (IA), a total of 29 applications for DTS operations were filed, and 19 construction permits were granted, DTS stations constructed, and DTS licenses issued. Of those DTS applications and constructed facilities, MWG was responsible for the designs, applications, construction, and licensing of more than one-quarter of the DTS stations in each category. The DTS networks ranged from simple, two-transmitter networks up to networks having five and eight transmitters. The one with eight transmitters was built on a first-adjacent-channel to another, single-transmitter station in the same market. Another was built with a high-power DTS transmitter near the edge of the station's authorized service area in order to provide service to a large population center located there. The various DTS networks successfully applied all of the available types of signal delivery to the transmitters, including microwave, satellite and fiber-optic Studio-to-Transmitter Links (STLs). The comments that follow draw upon this experience to reflect the real-world challenges that must be overcome to achieve the potential benefits that DTS operation offers – in particular, in an environment in which ATSC 3.0 can grow to become the primary over-the-air digital television delivery system.

ATSC 3.0 vs ATSC 1.0 Technology and DTS Networks

The current DTS rules were promulgated before work on ATSC 3.0 began in late 2011. They were written with the limitations in mind of what is now called "ATSC 1.0" – based on ATSC A/53, the ATSC Digital Television Standard. The ATSC 1.0 technology uses a single carrier modulated with a great number of data "symbols" per second, each symbol carrying a small number of bits, and it depends on there being "adaptive equalizers" in receivers to filter out the multipath signals created by naturally-occurring echoes in the transmission environment.

Built into the concept of ATSC 1.0 DTS networks, there was an expectation that the signals from the several transmitters in a DTS network would be kept separate from one another to the extent possible in order to minimize the burden placed on receiver adaptive equalizers but that the signals from multiple transmitters in a DTS network would be treated as echoes of one another by adaptive equalizers in areas where the signals did overlap. Indeed, performance of adaptive equalizers was a limiting factor in what could be done in designing a DTS network, and a starting point for such a design was determining what level of performance could be expected from the adaptive equalizers found in real-world receivers.

Using the adaptive equalizer characteristics found in receivers, areas where signals from DTS transmitters were predicted to overlap could be minimized through use of terrain shielding, carefully designed antenna patterns, and other methods. DTS networks using ATSC 1.0 could be built to operate effectively, but they were a late addition that had not been contemplated during the design of the ATSC 1.0 technology. Consequently, ATSC 1.0 DTS networks require careful design, often need specially-constructed antennas, and thus can be quite expensive to build. Those factors, combined with the late adoption of rules permitting DTS operations, contributed to the relatively small number of DTS operations that were constructed prior to the pre-IA application freeze.

ATSC 3.0, on the other hand, uses a form of modulation that is designed to support SFNs in DTS-style operations. It has a very large number of carriers (in the many thousands), with the symbol rate on each carrier being relatively low and the number of bits per symbol being either low or moderate. It does not require an adaptive equalizer, although one can be used. Instead, it has a transmission characteristic that makes it possible for receivers to ignore periods when echoes (either naturally occurring or man-made – as from the multiple signals in a DTS network) occur. The characteristic that deals with echoes is called a Guard Interval, which is a period during each symbol time when echoes occur at symbol transitions and which is ignored by receivers. The Guard Interval is filled with a Cyclic Prefix by the modulator and often is called by that name. Since the Guard Interval can have different lengths, as determined at the transmitter, its length is signaled to receivers, and all of them are expected to behave identically in response.

Through setting of a parameter for the length of the Guard Interval, different durations of echoes can be caused to be ignored by receivers. Thus, for DTS networks, the amount of overlap of signals from different transmitters can be compensated in receivers through the mechanism of setting the Guard Interval value. Unlike ATSC 1.0 DTS networks, for which it is necessary to keep the signals from multiple transmitters from overlapping insofar as possible, with ATSC 3.0, signals from several transmitters can be allowed to overlap, and the overlap can be compensated. Indeed, the overlap can help to improve reception. The result is that operation of ATSC 3.0 DTS networks will be far more predictable in their results and will be easier to design and manage.

Another very significant difference between ATSC 1.0 and ATSC 3.0 is the ability in ATSC 3.0 to partition the resources of the channel into different operating conditions having different combinations of signal robustness and capacity to deliver data reliably. In ATSC 1.0, there was only one such operating point, and only one fundamental type of receiver could be served. With ATSC 3.0, many different operating points are possible with respect to the robustness/channel capacity tradeoff, and many different types of receivers and forms of reception can be served as a consequence. To obtain maximum benefit from the capabilities of ATSC 3.0, the spectrum must be used efficiently, which demands that signal levels delivered throughout a broadcast station's service area be as uniform as possible, which, in turn, is the basic rationale for the use of DTS networks.

As a consequence of the relative ease of building ATSC 3.0 DTS networks and the many other new features of ATSC 3.0, there is considerably more interest among broadcasters in building DTS networks using ATSC 3.0 than there was using ATSC 1.0. Indeed, there are broadcasters who expect to convert their operations completely from single-transmitter facilities to DTS networks in order to take advantage of many of the new capabilities of ATSC 3.0 offered by its technology, such as reliable delivery of data to mobile and portable devices. To justify investments in such innovations in broadcast systems, the regulatory environment must permit broadcasters to take full advantage of the new technical potential offered by ATSC 3.0. Such a regulatory environment does not exist under certain aspects of the current rules for DTS networks, which were based on ATSC 1.0 technology and also lack of real world experience in constructing such networks.

Deficiencies in Current DTS Rules

To understand the suggestions made below for improvements in the rules for DTS networks to facilitate their use with ATSC 3.0 broadcasting, it helps to examine the operation of DTS networks under the rules as they exist. For that purpose, a series of maps will be used to show examples of the consequences of the current DTS rules and then to look at possibilities to make those rules more practical for implementation of DTS networks. In looking at the maps, it is important to recognize that signal levels will be the same for a given transmitted power level, regardless of the type of modulation used. The power levels and other facility characteristics will be described without regard to the type of modulation applied. The implication is that the suggestions to be made also would be effective in improving DTS networks for ATSC 1.0 operation, but no more of those are expected to be constructed because of the significant improvements that can be obtained using ATSC 3.0 technology.

To start, please consider a single transmitter, the antenna for which is over "flat earth." The antenna will have identical values for the height of its radiation center above ground level (RCAGL), height of its radiation center above average terrain (RCHAAT), and, if the ground is at sea level, height of its radiation center above mean sea level (RCAMSL) – all values that are used by the FCC for a variety of purposes. To make sure that all of these conditions apply, the map in Figure 1 below and those to follow locate a television station (labeled DTS1) in the middle of the Atlantic Ocean, where the software used to generate the maps will treat the terrain

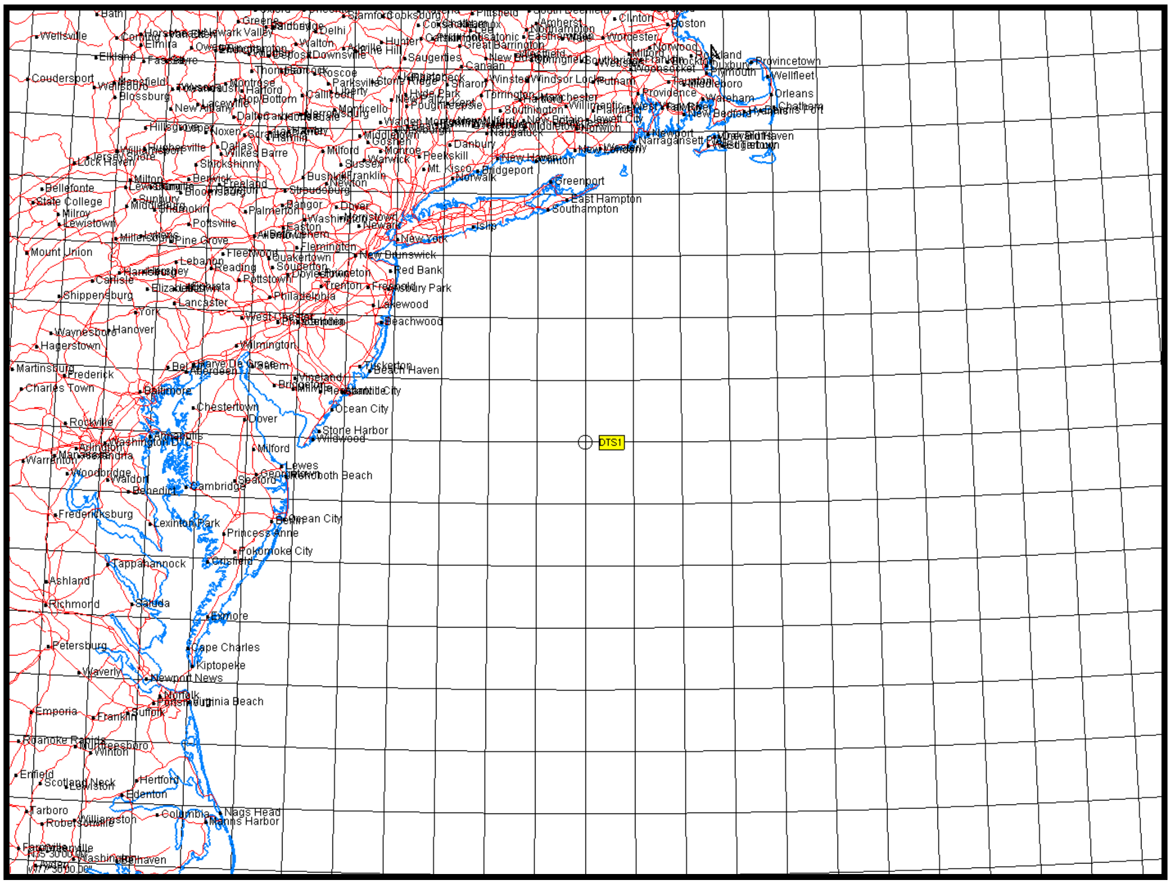

Figure 1 – DTS1 Transmitter Location over Flat Earth

as being flat and at mean sea level. The software will treat the surface as being land, not water, so the results will be correct for "flat earth."

The DTS rules in §73.626(c) specify a Table of Distances, the values of which for the different spectrum bands and zones are used to constrain the locations of transmitters and the distances that contours can be from reference points for DTS networks. The Table of Distances values specify the radii of circles that can be drawn around the reference points. Those circles, or contours associated with particular stations that exceed the circle radii in certain directions, determine where DTS transmitters can be located and where the contours of signals from those DTS transmitters must be contained. Figure 2 shows an example of a Table of Distances circle for a station on Channel 38, where the field strength of 41 dBu used as a reference (at 615 MHz) in the rules and in OET Bulletin No. 69 applies without compensation by the “dipole factor.”

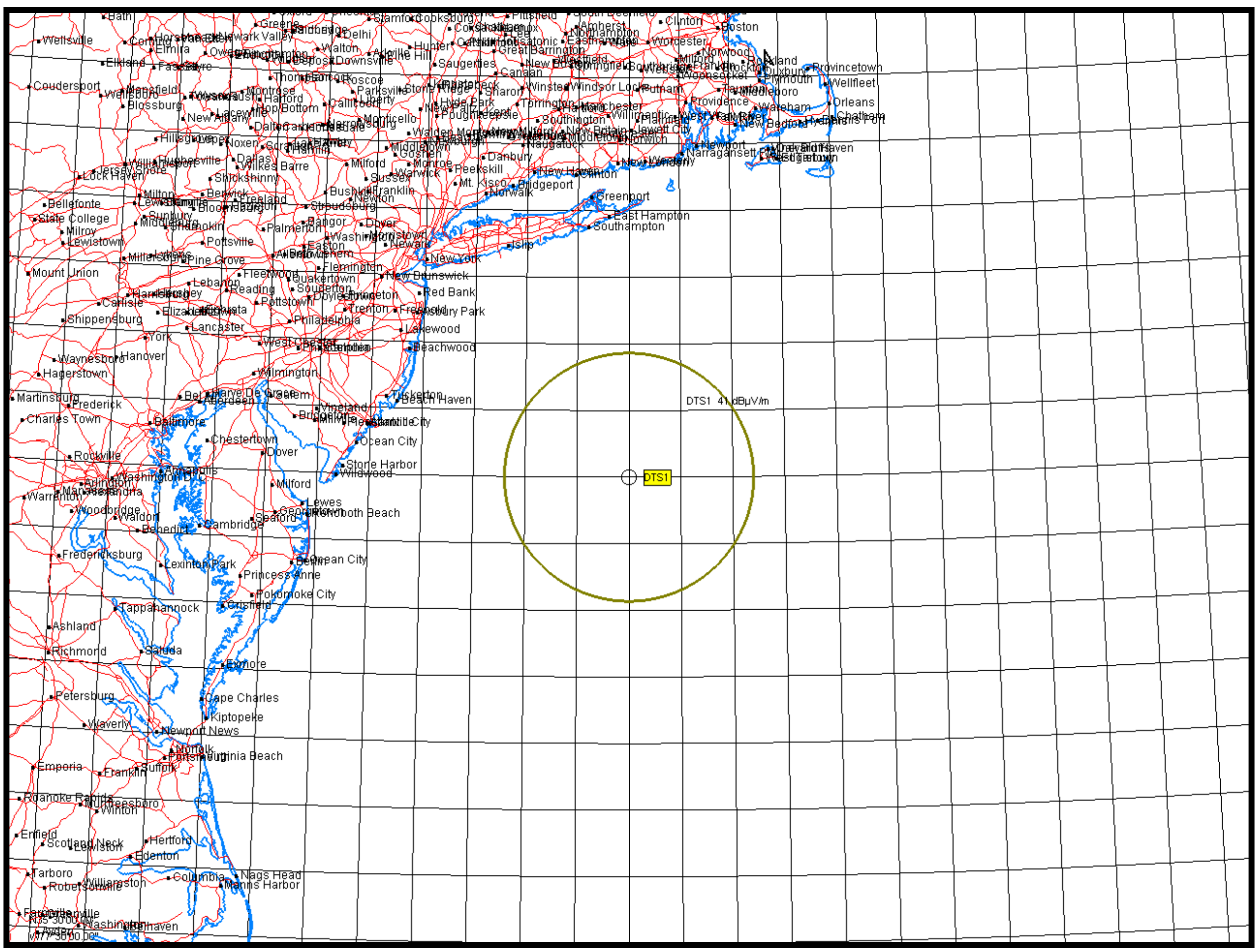

Figure 2 – DTS1 Transmitter over Flat Earth with Table of Distances Circle

The radius of the Table of Distances circle for a UHF station was derived from the contour distance of a hypothetical, maximized facility, operating over flat earth, and configured according to the operating values in §73.622(f)(8) (i.e., 1000 kW at 365 m HAAT). That is the configuration shown in Figure 2 for a station labeled DTS1 located at the reference point for the DTS station. As a consequence of the frequency used in this example, the limiting contour value is 41 dBu, and the distance to the contour is 103.5 km for desired signals having location and time statistics of F(50:90). (All contours in the maps presented in this discussion were created with software based on the charts in §73,699, as specified in §73.625(b) of the rules.) To simplify the presentation, non-directional (omnidirectional) antenna patterns will be shown on the maps; it is recognized that results often could be improved through use of directional antennas, as is discussed to some extent below.

Adding to the map of Figure 2 the field strength values predicted using the Longley-Rice terrain-based propagation model, as described in OET Bulletin No. 69, results in the map of Figure 3. In that map, the color coding yields yellow for signals stronger than 100 dBu, red for signals between 80 – 85 dBu, gray for signals between 60 – 70 dBu, and green and cyan for signals below 60 dBu. As a general rule, many consultants consider signal levels above 80 – 85 dBu (i.e., the red band and above) to be adequate for indoor reception and signal levels above 60 dBu or so (i.e., the blue band and above) to be adequate for outdoor reception. Studies conducted by ATSC in the early 2000’s found that reception in the range below 50 – 60 dBu (i.e., the green and cyan bands) would be unreliable, even for outdoor reception. Note that the Table of Distances circle remains evident just at the outside end of the green band.

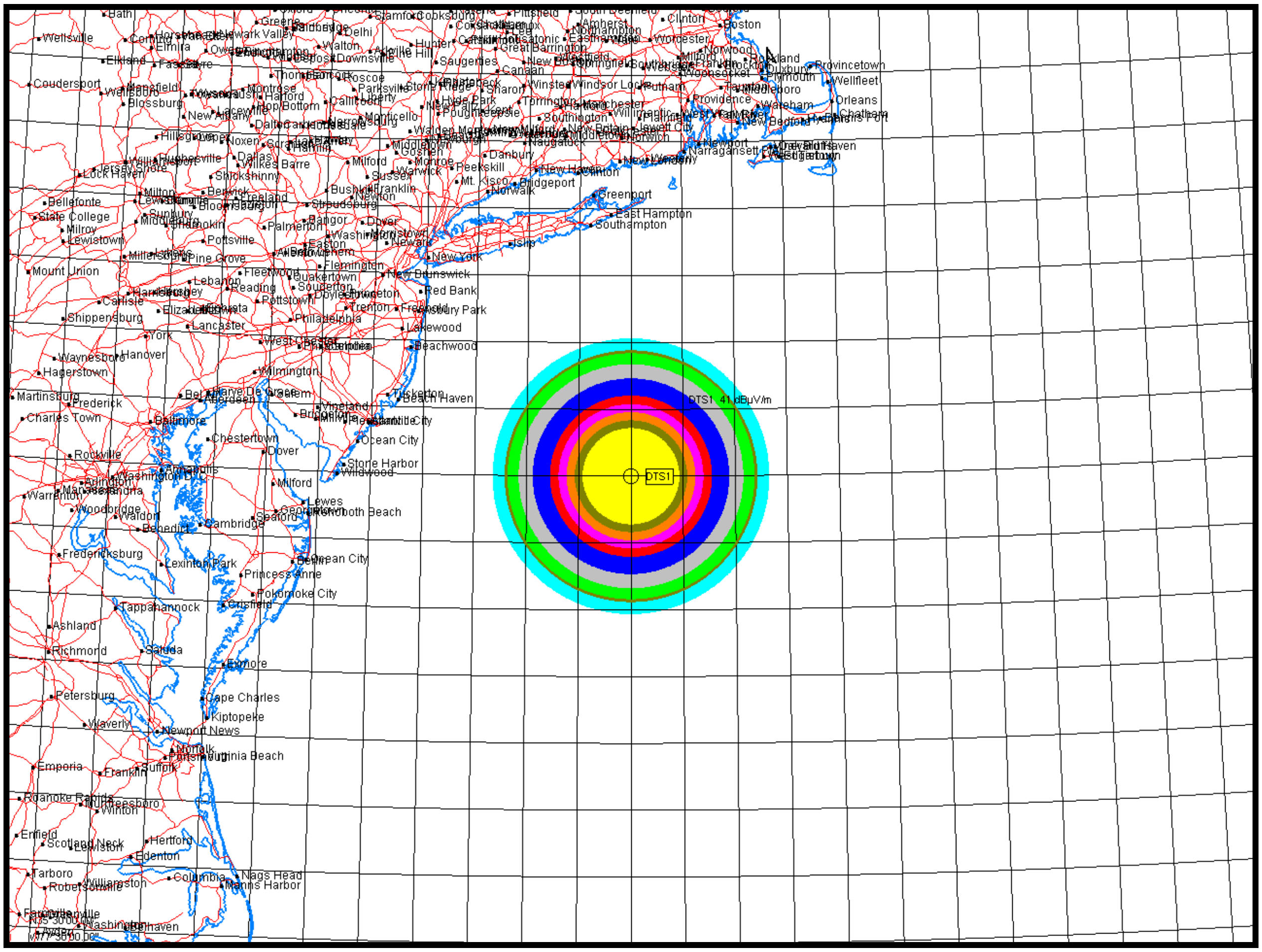

Figure 3 – DTS1 Transmitter over Flat Earth with Table of Distances Circle and Longley-Rice Field Strength

In Figure 3, reception in the green and cyan bands is expected to be unreliable and often unavailable as a general matter because of the low signal levels. This indicates that there are large areas inside the so-called predicted noise-limited contour (PNLC), which is the same as the Table of Distances circle, where no service is provided despite the area being inside the service contour.

When a station is predicted to provide service in the areas shown in Figure 3, it causes interference in a much wider area. This can be seen in Figure 4. For co-channel signals, the Desired-to-Undesired (D/U) signal ratio at the threshold of interference is 15 dB. That means that signals 15 dB weaker than the desired signal, but with (F50:10) location and time statistics, will cause interference. If a signal can just be received at 41 dBu, a signal at 26 dBu will cause interference to it. In fact, that relationship is true at higher signal levels, and even more amplitude separation (up to 21 dB instead of 15 dB) between the desired and undesired signal levels is required for reception at the weakest signal levels, but that factor will be disregarded for this discussion to simplify the matter. Doing so only will make the results to be shown more conservative.

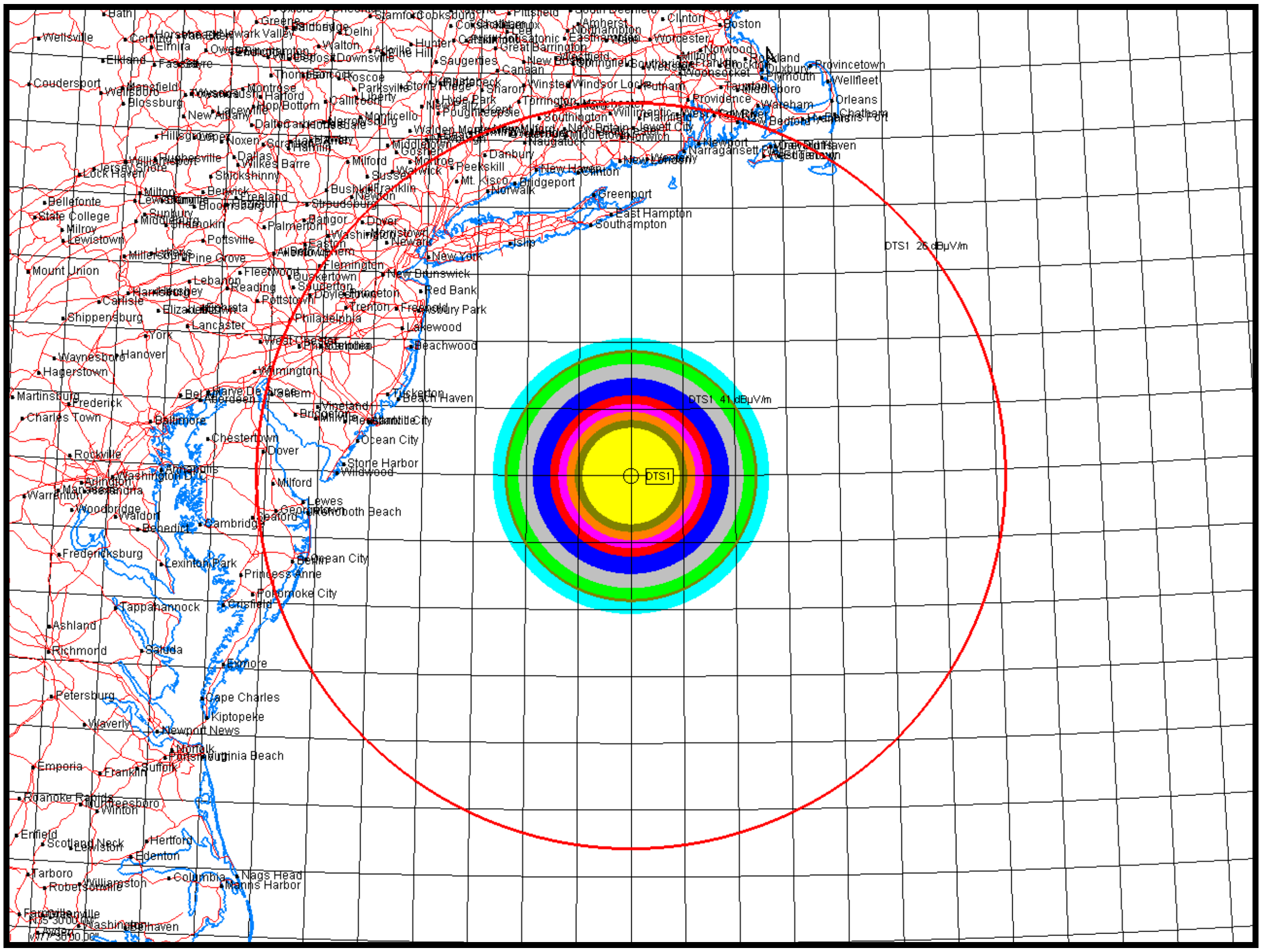

Figure 4 – DTS1 Transmitter with Table of Distances Circle and Co-Channel Interference Contour

In Figure 4, the red F(50:10) Interference Contour has a radius (309.9 km) approximately three times the radius (310.5 km) of the F(50:90) Service Contour, as represented by the Table of Distances circle. This confirms a general rule of thumb with respect to the planning factors selected by the FCC Advisory Committee on Advanced Television Service for what became the ATSC Digital Television Standard that the Interference Contour has approximately three times the radius of the Service Contour. The contours in the maps herein all were generated using software that follows the requirements of §73.625(b) of the rules.

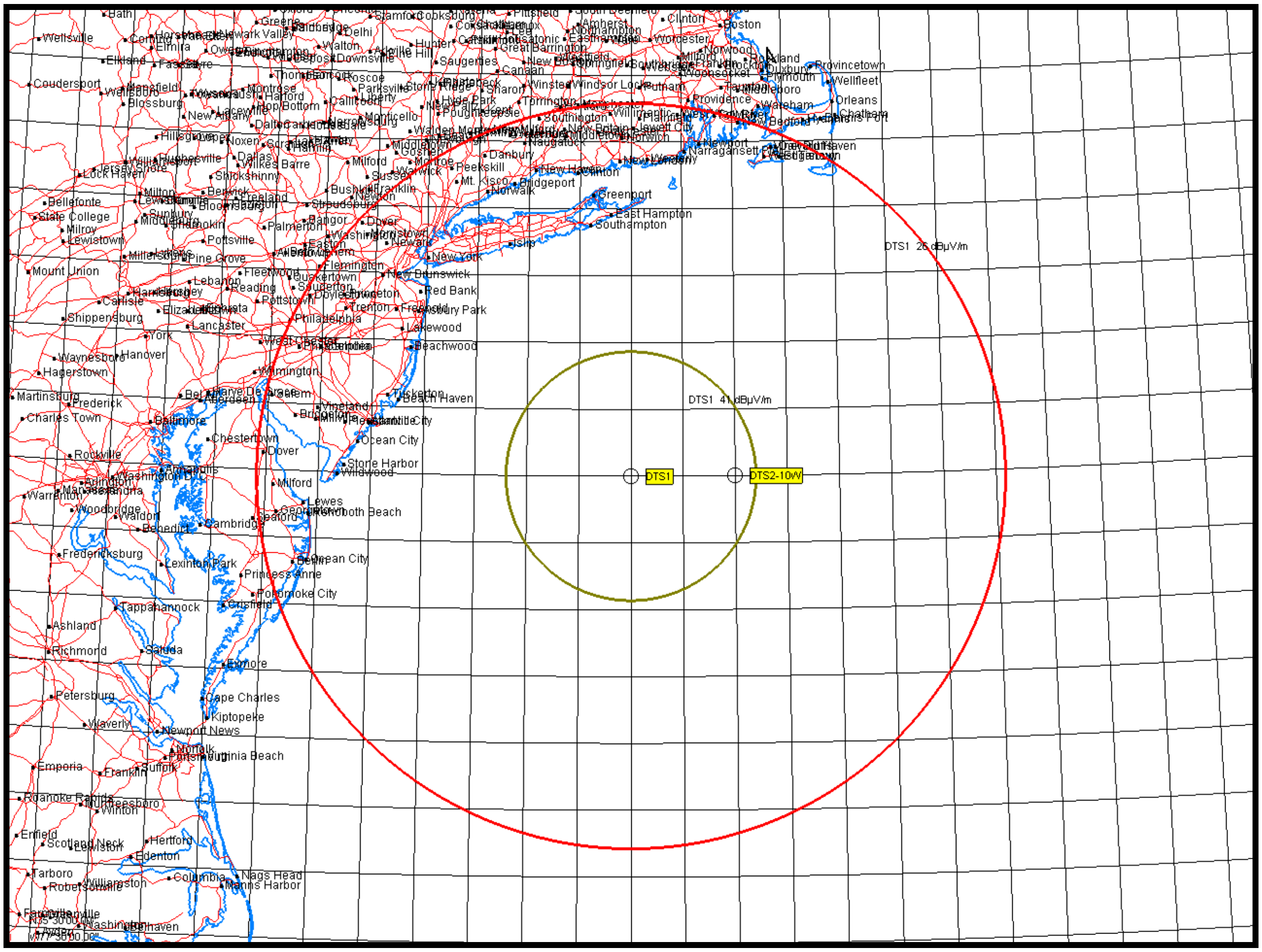

Figure 5 –DTS1 Transmitter Table of Distances Service Area with Added DTS2 Transmitter Location

With the basic characteristics of a single transmitter facility having been shown, the next map, in Figure 5, shows the addition of a DTS2 transmitter toward the east side of the Table of Distances service area. The DTS2 transmitter has been located arbitrarily at a grid intersection on the map, similar to what occurs when a tower that can support a DTS transmitter happens to be available at a random location in the general area where one is needed. In this case, the DTS2 transmitter is positioned due east of DTS1 at a distance approximately 83.5 percent of the way along the Table of Distances radius.

To look at what can be done under the current DTS rules, Figure 6 shows the contour of the DTS2 transmitter with its contour contained within the limiting line of the DTS1 Table of Distances circle. This is as required by §73.626(f)(2). The DTS2 transmitter antenna is at100 m AGL – about 328 feet. To make the DTS2 contour fit within the service area of DTS1, the DTS2 effective radiated power (ERP) had to be set to just 10 watts. The effect of that power level will be examined next.

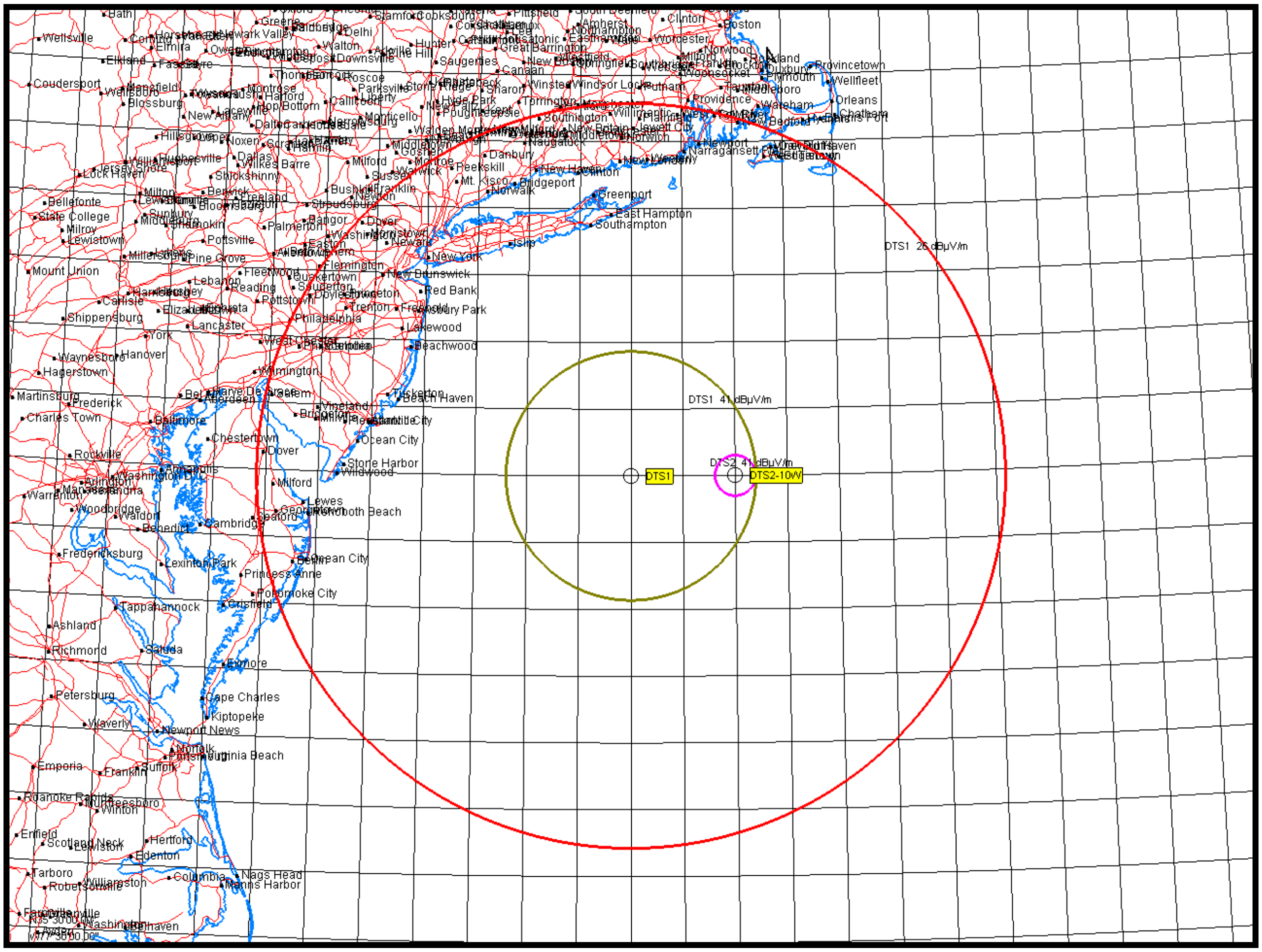

Figure 6 – DTS1 Transmitter Table of Distances Service Area with DTS2 Contiguous Contour

To make the relationships more apparent, in Figure 7, the map is zoomed in to a smaller scale. The fact that the DTS2 41-dBu contour just touches the DTS1 41-dBu contour (which corresponds to the Table of Distances circle limiting line) now is more readily visible.

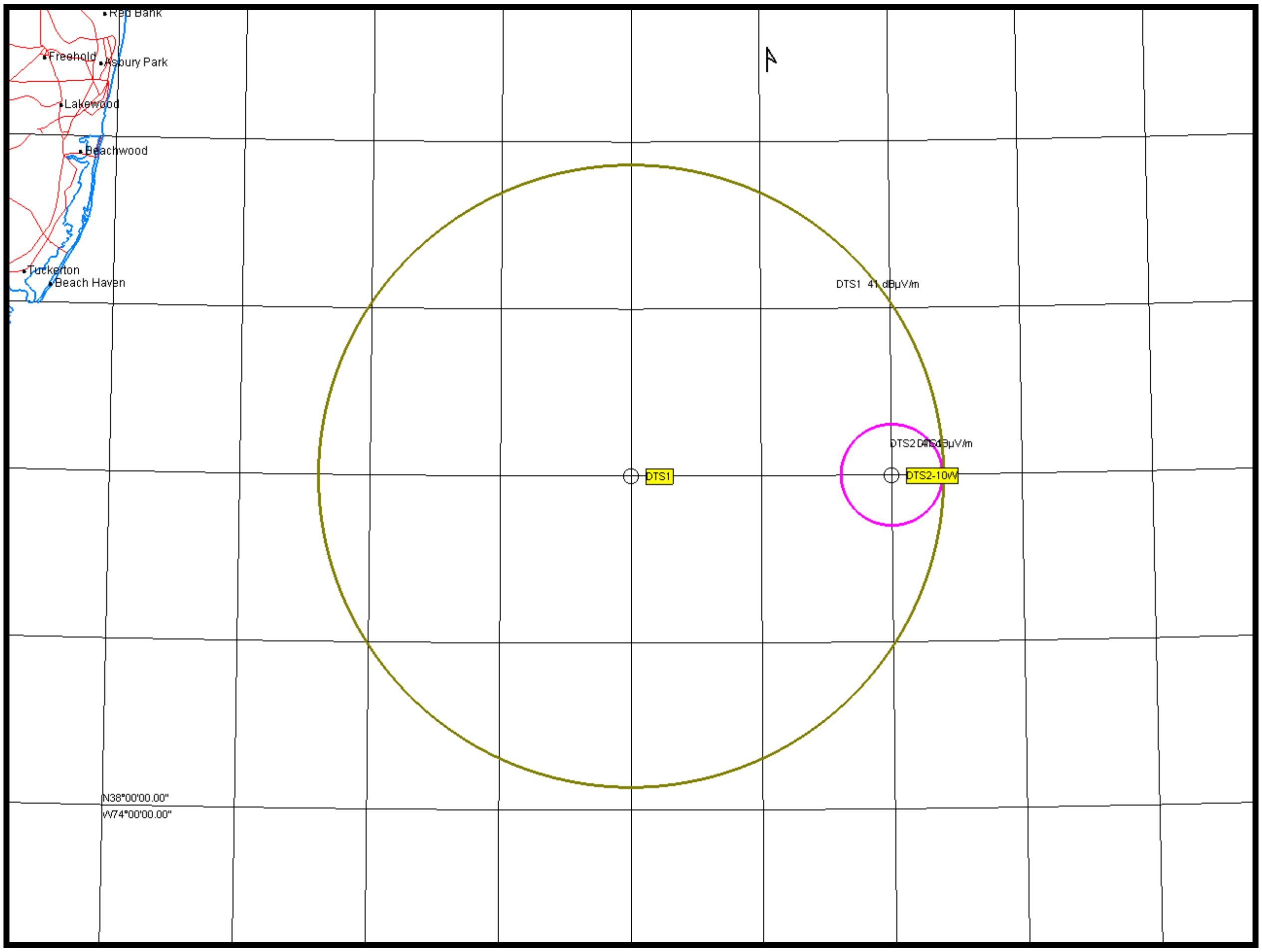

Figure 7 – DTS1 with Table of Distances Circle and Contour & DTS2 with 10 W ERP Contour – Zoomed In

In Figure 8, the color-coded Longley-Rice field strength information is added back onto the map. As can be seen the DTS2 transmitter is within the gray region predicted to receive signal levels between 60 – 70 dBu. As a reminder, the yellow region has predicted field strength values greater than 100 dBu; the red band and above have predicted field strength values greater than 80 dBu and generally would be considered to provide for reliable indoor reception; the gray band and above have predicted field strength values greater than 60 dBu and generally would be considered to provide for reliable outdoor reception; and the green and cyan regions have predicted field strength values greater than 50 dBu and 41 dBu, respectively, and generally would be considered not to provide reliable reception. The implication of the inability to reliably receive television signals in the outer reaches of a station's authorized service area is that there are populations in those areas who will not receive usable service without going to extraordinary means such as installation of towers on which to mount receiving antennas.

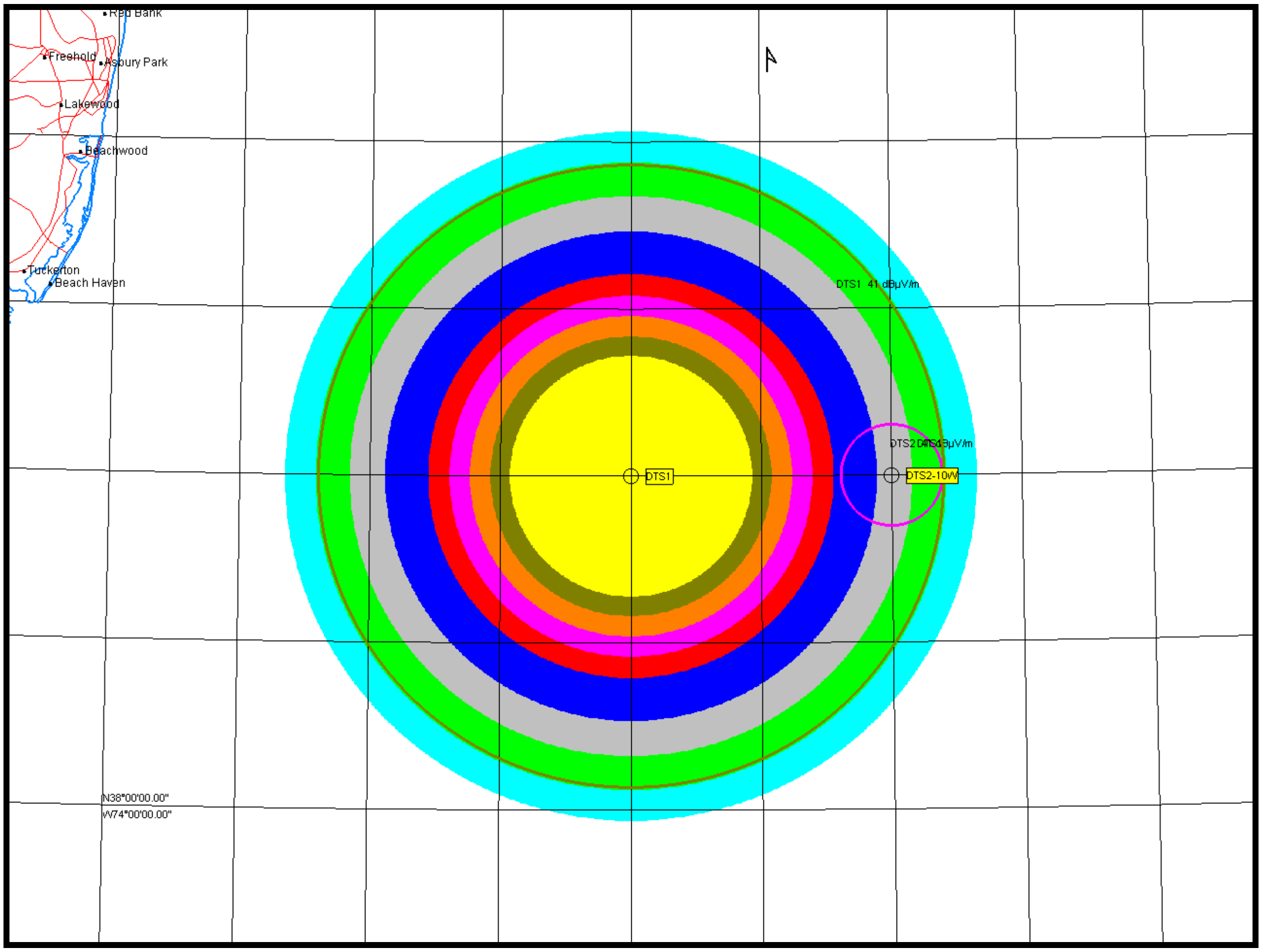

Figure 8 – DTS1 with Table of Distances Circle and Contour and DTS2 with 10-W ERP Contour

Figure 9 shows the impact of adding the DTS2 transmitter to DTS1 to create a DTS network. The improvement in Longley-Rice predicted field strength from the addition of DTS2 is shown. There is a very small circle within the gray 60 – 70 dBu band where predicted signal levels are increased to be above 70 dBu (as represented by blue), and right around the transmitter there is an even smaller region in which the predicted signal levels are increased to be above 80 dBu, where indoor reception would be expected.

Also shown in Figure 9 is the 26 dBu Interference Contour of the DTS2 transmitter. It will become significant in the discussion to follow later in these comments.

The expected reception capabilities of the various signal levels generally have been derived from experience with ATSC 1.0, and it could be argued that ATSC 3.0 has the ability to operate at much higher levels of robustness than does ATSC 1.0, corresponding to lower threshold field

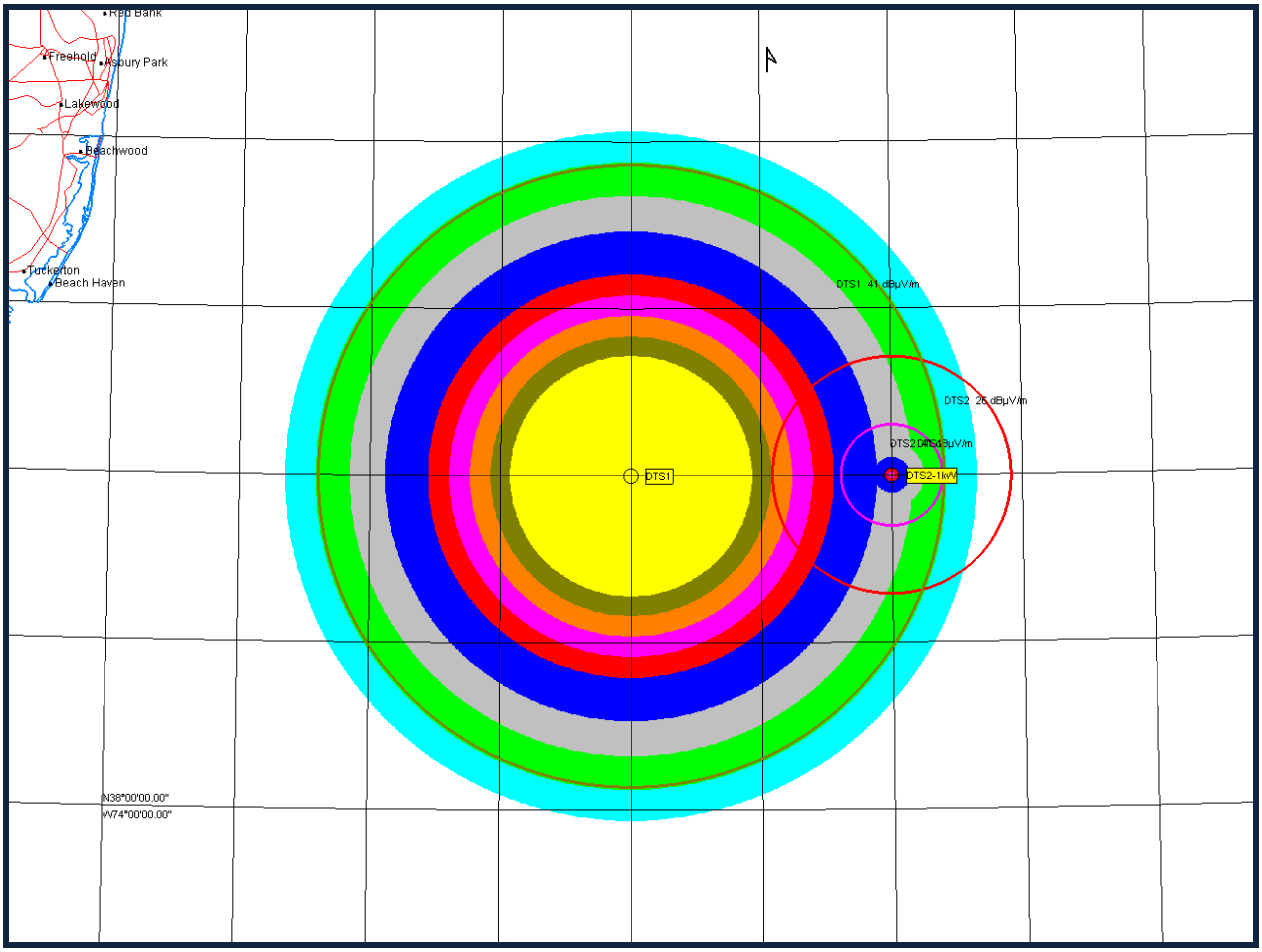

Figure 9 – Impact of Addition of DTS2 to Predicted Field Strength from DTS1 Transmitter

strengths. That assertion is true, but it misses a very important factor: To make reception possible in the regions where signal levels are very low, a great deal of the capacity of the channel must be sacrificed to achieve those results since there is a tradeoff required between robustness and data carrying capacity of the signals. That tradeoff would have to be made throughout the service area, meaning that even places with high signal levels would receive far less through the channel than the channel is capable of delivering. A much better solution, from the perspective of using the channel efficiently, is to increase power where signal levels would be low, to make signal levels more uniform throughout the service area, thereby enabling use of as much of the channel capacity as possible. Then, the highly robust configurations possible with ATSC 3.0 can be applied to extend service in higher signal level areas for reception inside buildings and to small handheld devices, as now is routinely expected by the viewing public, rather than wasting that capability just to deliver a small amount of data to the outer reaches of a station's authorized service area.

With the objective in mind of providing more uniform signal levels throughout a service area, the question naturally arises as to what the objective should be for the signal level to be made uniform. Since the expectation on the part of the viewing public is indoor reception, a uniform field strength of 80 – 85 dBu or better is indicated as the target for network design. Figure 10, then, begins an evaluation of what is required to achieve a more uniform signal level throughout a service area with a target field strength of 80 dBu or greater. It shows the same DTS2 facility as before but with the ERP increased by 20 dB to 1 kW.

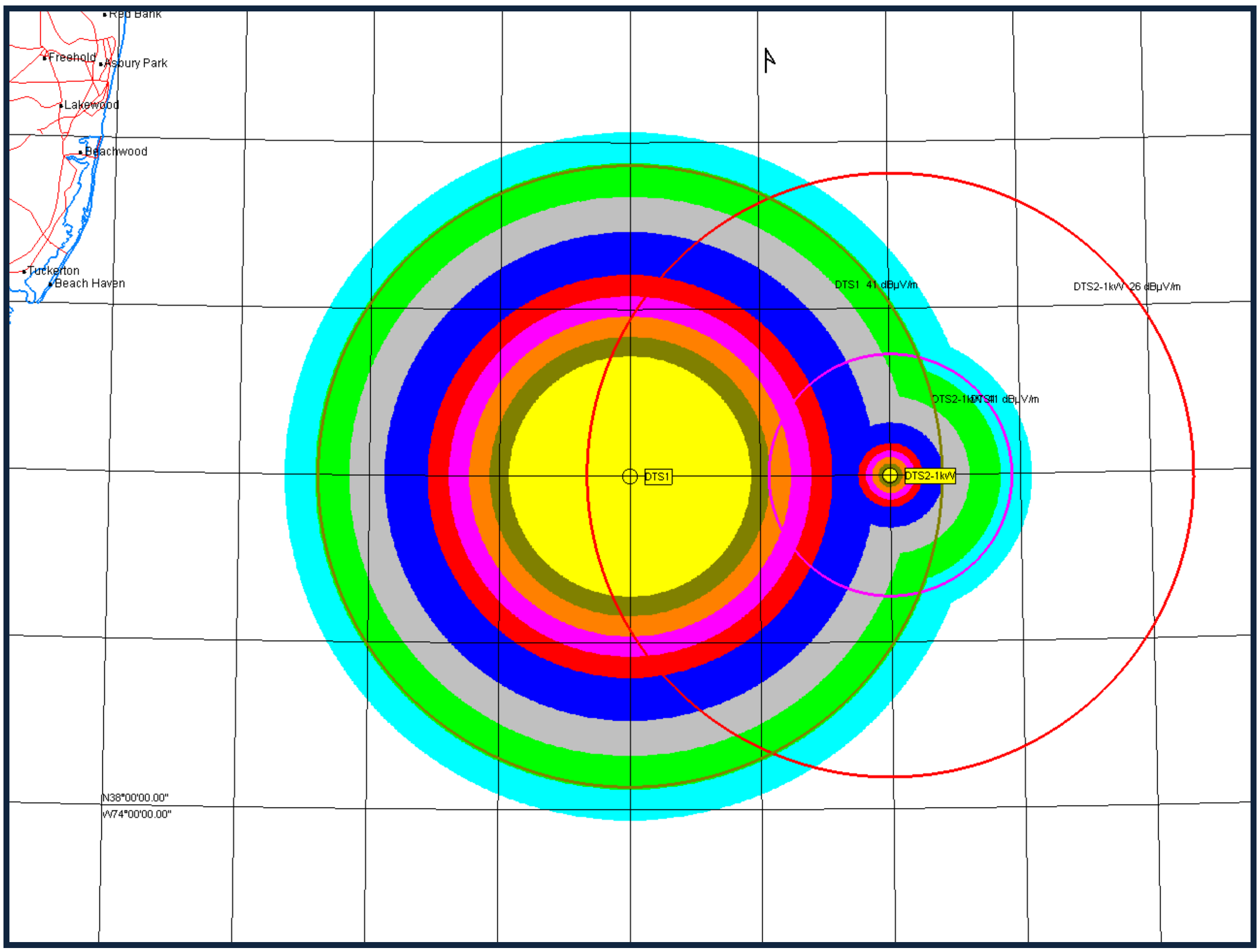

Figure 10 – DTS2 Increased to 1 kW ERP, Showing Effects on Contours and Longley-Rice Field Strength

In the case shown in Figure 10, the signal level is increased to greater than 80 dBu in a small area surrounding the transmitter but neither to the boundary of the service area nor to join with the area surrounding DTS1 that achieves the target signal level. A higher transmitted power level still is needed from DTS2.

Another increase of 20 dB in the DTS2 transmitted ERP – to 100 kW – is shown in Figure 11. The DTS2 80-dBu color band (red) now connects with the same band surrounding DTS1. That color band extends further than needed, exceeding the Table of Distances circle limit line, but that could be adjusted with use of a directional antenna, if required. Use of directional antennas will be discussed below. Important to note in Figure 11 is that to provide good service up to the edge of the service area, the PNLC of the DTS transmitter must, of necessity, go beyond the PNLC of the hypothetical transmitter on which the Table of Distances was based.

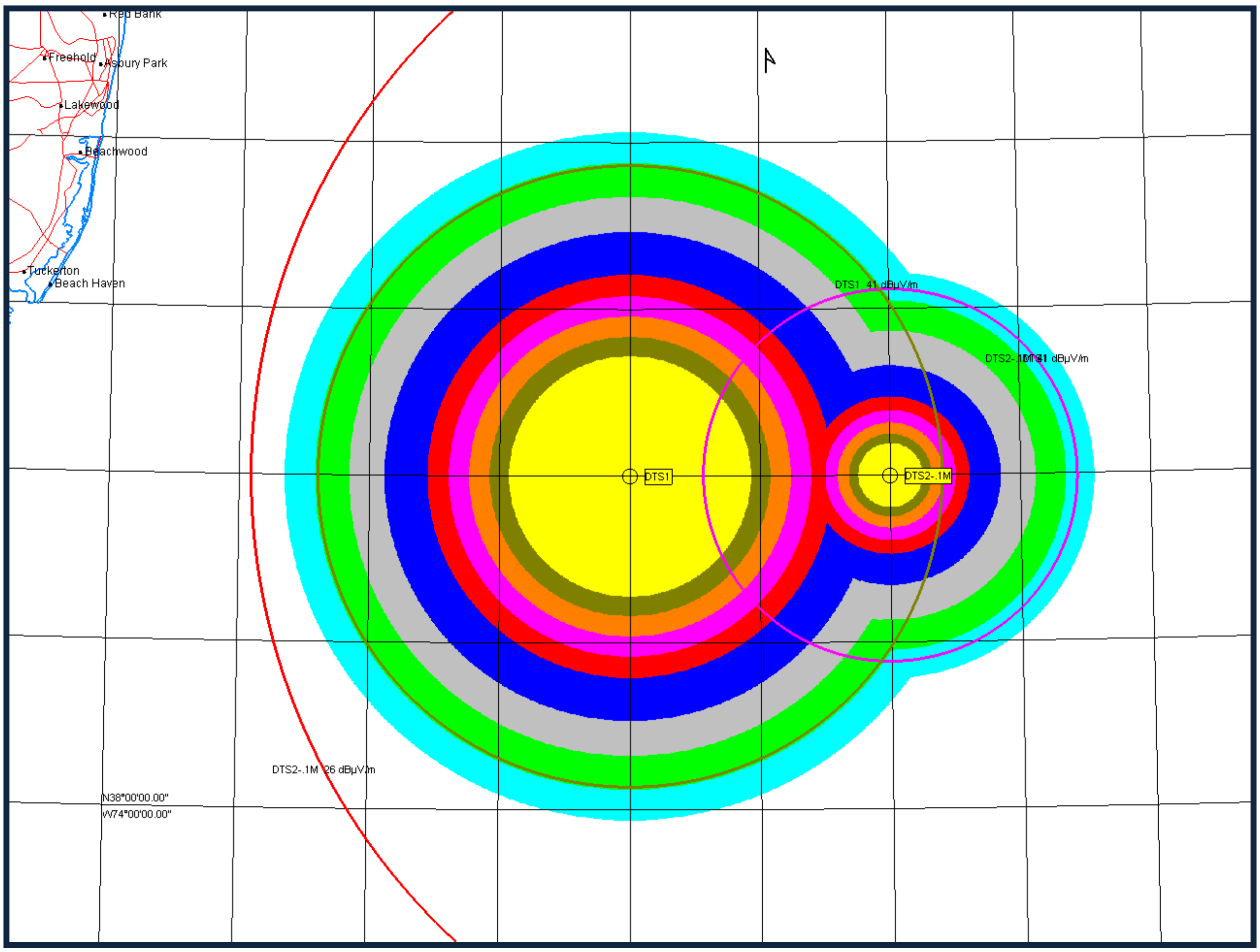

Figure 11 – DTS2 Increased to 100 kW, Showing Effects on Contours and Longley-Rice Field Strength

The important message of Figure 11 is that, if good service is to be provided throughout a service area, then matching of the PNLC contours of the various transmitters cannot be used to limit the signals from the multiple transmitters in the service area at the service area boundary. Some other mechanism must be found to provide the necessary limitation while still enabling high quality service to the full service area.

Suggested Improvements in DTS Rules

To maximize the benefits of implementation of DTS networks by broadcasters using the much improved technology of ATSC 3.0 and to make their investments in DTS beneficial for all, an improved method must be found to limit where the signals from DTS transmitters can go and at what signal strengths. The following discussion is intended to support the idea that the method used should be a limitation of the interference zone surrounding a DTS network rather than directly of the service area itself. It is believed that such a change can be accomplished with few adjustments to the DTS rules themselves, with only a small impact on the TVStudy software, and with virtually no additional burden on Commission staff in the processing of DTS applications.

In addition to making an improved regime for managing the characteristics of DTS networks a low burden for the FCC's application processing functions, it also needs to be practical for broadcaster implementation. One of the main burdens of the current scheme on broadcasters who want to reach the bulk of their service areas has been financial. To place strong signals near the edges of the service area has required very expensive directional antennas. Instead of antenna costs on the order of a couple to a few tens of thousands of dollars, antennas costing on the order of five times as much have been required. Such antennas, instead of being common, practically off-the-shelf equipment, have been design-intensive, heavily customized items that have been expensive to install as well as to design and build. Consequently, finding a method for constraining the service of DTS networks while enabling broadcaster use of reasonably-priced antennas will be a prerequisite for a wide proliferation of the technology throughout the television broadcast industry. The impact on antenna complexity and costs of the method chosen will be an important aspect of the following discussion.

To begin to examine a possible alternative method for constraining DTS operations to definable bounds, Figure 12 shows the DTS network of Figure 11 zoomed out to a larger scale that includes the red 26-dBu Interference Contours of both the DTS1 and DTS2 transmitters. DTS1 remains a 1 MW omnidirectional facility with its center of radiation at 365 m AGL, HAAT, and

AMSL. DTS2 remains a 100 kW omnidirectional facility with its center of radiation at 100 m AGL, HAAT, and AMSL.

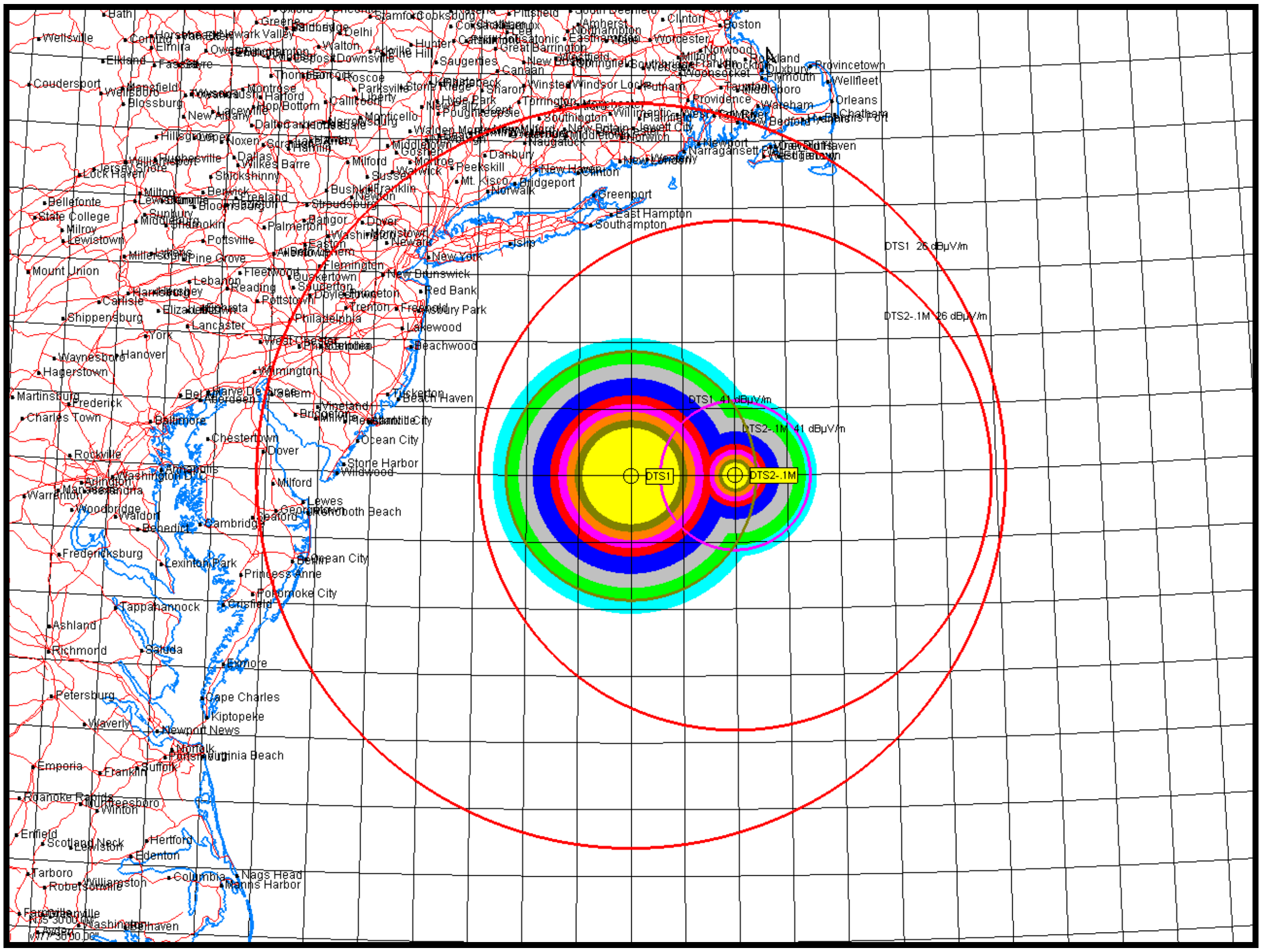

Figure 12 – DTS Network with DTS1 at 1 MW, DTS2 at 100 kW, Showing the 26-dBu Contours of Both

As can be seen in Figure 12, because of its lower height and lower power level, the DTS2 26-dBu Interference Contour falls completely inside the equivalent contour of DTS1. That fact immediately suggests the potential for continuing to constrain the locations of DTS transmitters to within the service area bounds (as currently prescribed by $73.626(f)(6)) of the station but modifying $73.626(f)(2) to constrain the interference contour of each transmitter to falling within the Interference Contour of the hypothetical facility that also establishes the service area boundary. While such a solution could be quickly arrived at, further examination shows that there are other factors that point to a variation on the theme.

Figure 13 adds another element to the picture. It is a co-channel Class A station, and its location is shown by the "LPTV" designation on the map. Its location was arbitrarily chosen in the same manner as the location of the DTS2 site was chosen – by placing it at an intersection of map coordinates to the east of the DTS network reference point.

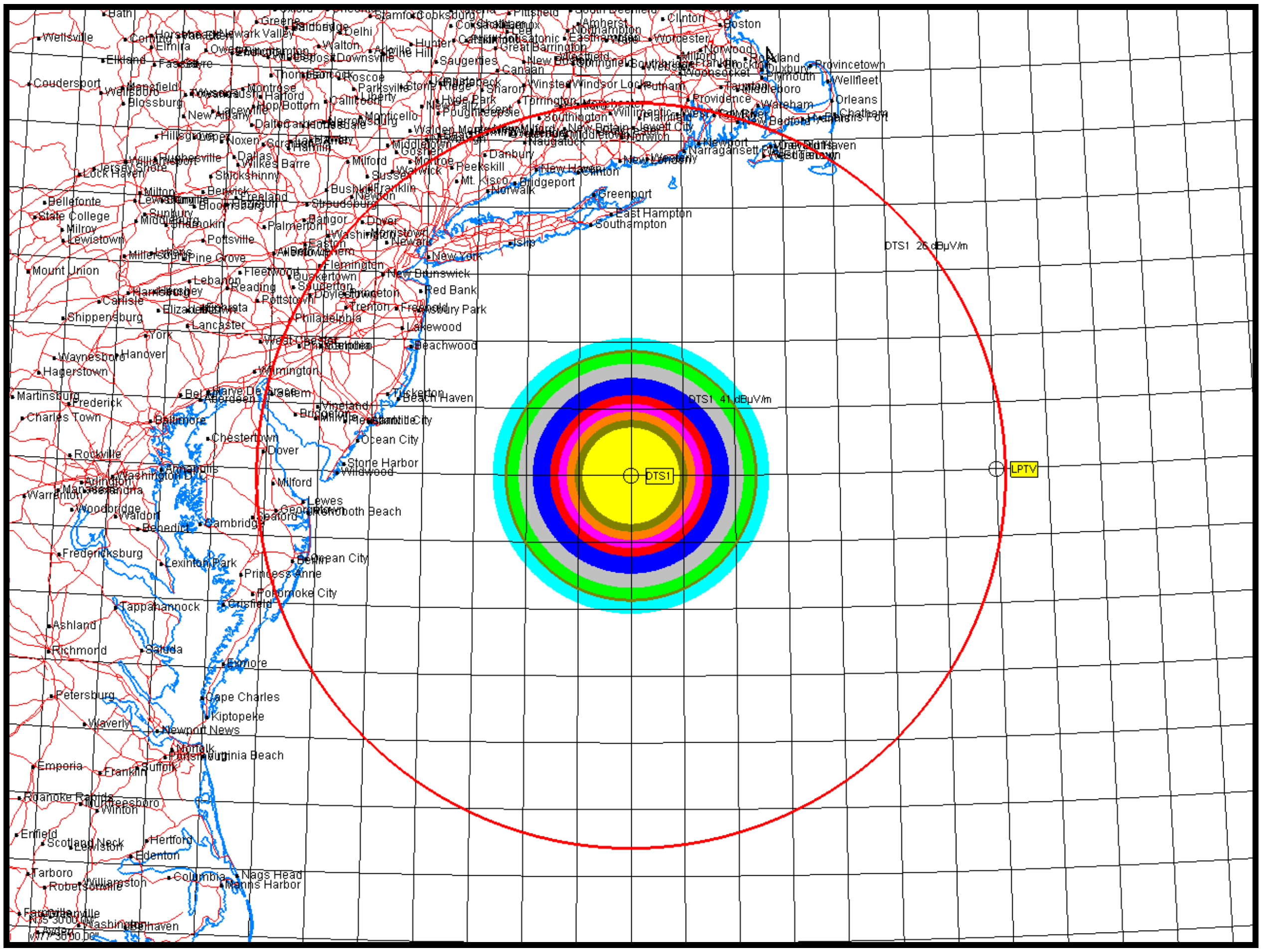

Figure 13 – DTS Network with Co-Channel Class A Location Shown (Labeled as "LPTV")

The Class A station in Figure 13 was modeled in Figure 14 as having its radiation center at 300 m (approximately 984 feet) for all of RCAGL, RCHAAT, and RCAMSL, due to the flat earth model. The ERP of the omnidirectional antenna was modeled as being 15 kW. In Figure 14, the details of the Class A operation are added along with the several relationships between it and the DTS network – in particular, the interference contours in both directions. UHF digital Class A stations have protected service contours of 51 dBu per §73.6010(c)(3). Similarly, UHF digital LPTV stations have protected service contours of 51 dBu, but they are not required to be protected by full service stations per §74.792(a).

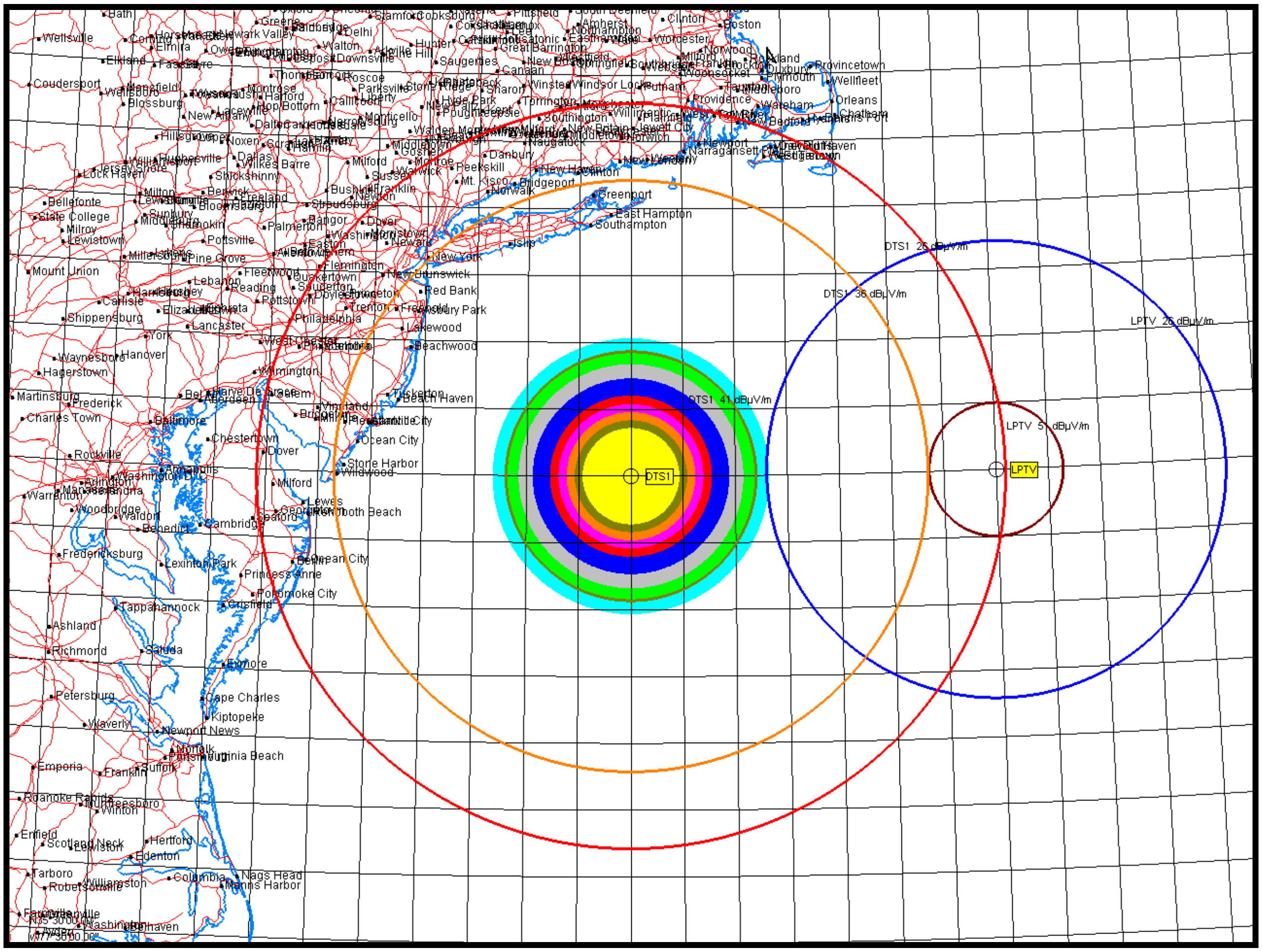

Figure 14 – Relationships between DTS Reference Station & Class A Station with 15 kW at 300 m

As mentioned above and described in the rules cited, protection to Class A stations normally is determined using contour methods at their 51 dBu F(50:90) contours. Interfering signals are analyzed using F(50:10) statistics in defining Interfering Contours. In Figure 14, the 51 dBu contour of the Class A station is in brown. The co-channel Interference Contour to the Class A station is the (51 – 15 =) 36 dBu contour, which is shown in orange for the DTS1 reference DTS facility. The Interference Contour from the Class A station to the DTS reference transmitter is the (41 – 15 =) 26 dBu contour, which is shown in blue for the Class A facility. In this case, the Class A station is assumed to have been built as close as possible to the DTS reference facility, and the orange and brown contours just touch for that reason. With the Class A facility described, the blue Interference Contour from the Class A station to the DTS reference facility falls short of the Table of Distances circle, which doubles as the protected service contour for the DTS network.

Figure 15 adds the 100 kW DTS2 transmitter back into the picture. Two things are important to notice in the figure: (1) The smaller orange contour surrounding the DTS2 transmitter does not touch the protected contour of the Class A station, so the Class A remains protected from the DTS network on a contour basis, and (2) The area with signal from the DTS 2 transmitter that falls within the blue Interference Contour of the Class A station is not entitled to protection because it falls outside the Table of Distances circle that determines the service area of the DTS operation.

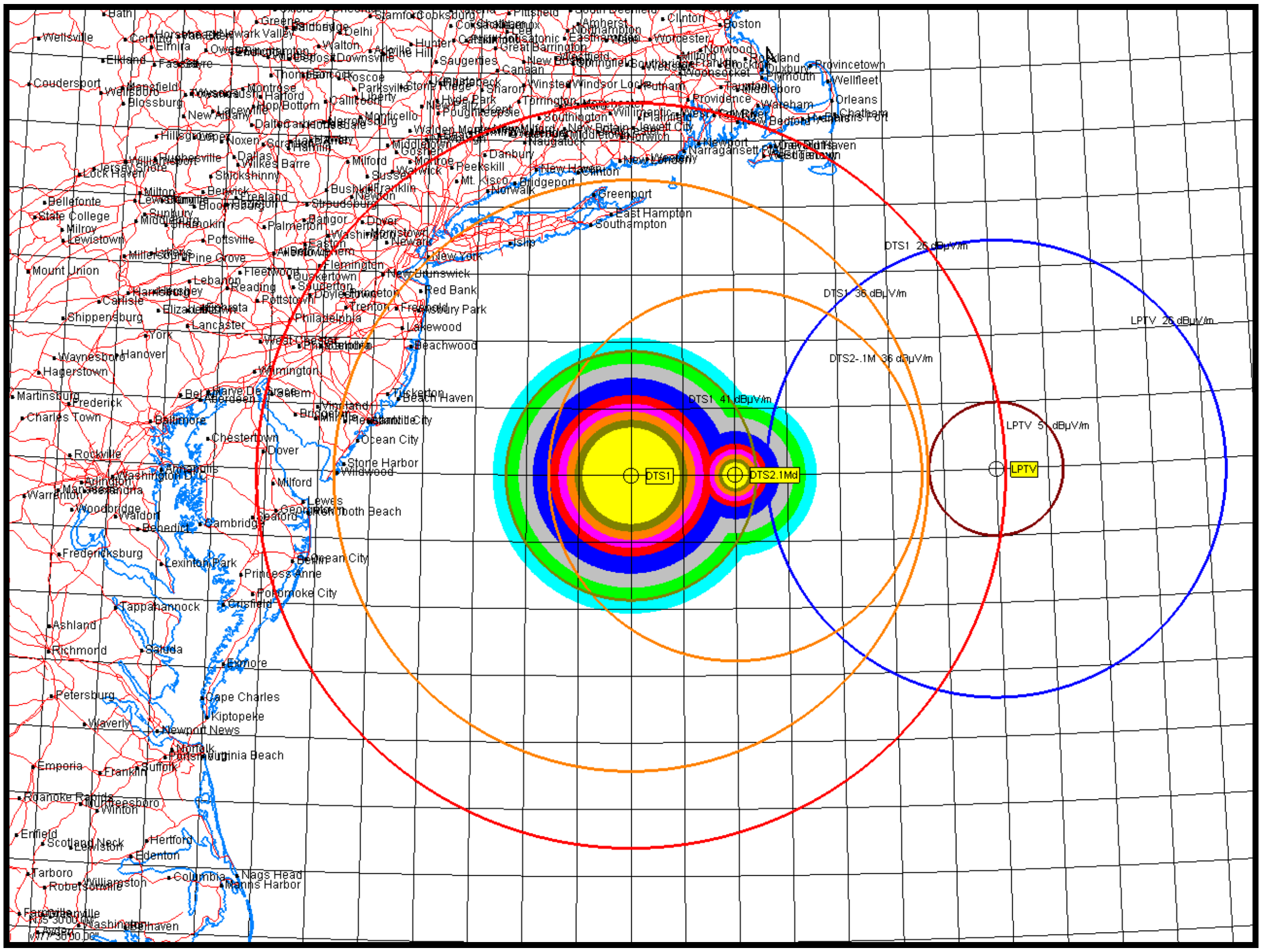

Figure 15 – Relationships between 2-Transmitter DTS Network & Co-Channel Class A with 15 kW at 300 m

Looking at the relationship between the DTS network and the Class A station from a non-contour perspective, there are provisions in the FCC rules that Longley-Rice terrain-based analyses can be used to show no impermissible interference in cases when contours do not provide the necessary showing. In such a case, the existence of the DTS2 transmitter actually can help the Class A station make such a showing. Without the presence of DTS2, in a Longley-

Rice analysis, the signals from the Class A station would have to be below 26 dBu at locations within the Table of Distances circle (or other relevant limit line) that just qualify as having service from the DTS1 transmitter, and there would be a large band of them. With DTS2 present, the signal levels will be much higher in the same locations, and, consequently, the Class A signals can be much higher, too. For example, where the DTS1 signals might have been at 41 dBu but with DTS2 are at 81 dBu, the Class A signals can be 40 dB stronger (i.e., 66 dBu instead of 26 dBu) before being considered to cause interference. That will permit the Class A station to have much stronger signals in its own protected service area or to be significantly closer to the DTS network without causing interference to it. As shown earlier with respect to the contour analysis, however, the presence of the DTS2 transmitter will not impact interference to the Class A unless Longley-Rice methods are used in that direction as well.

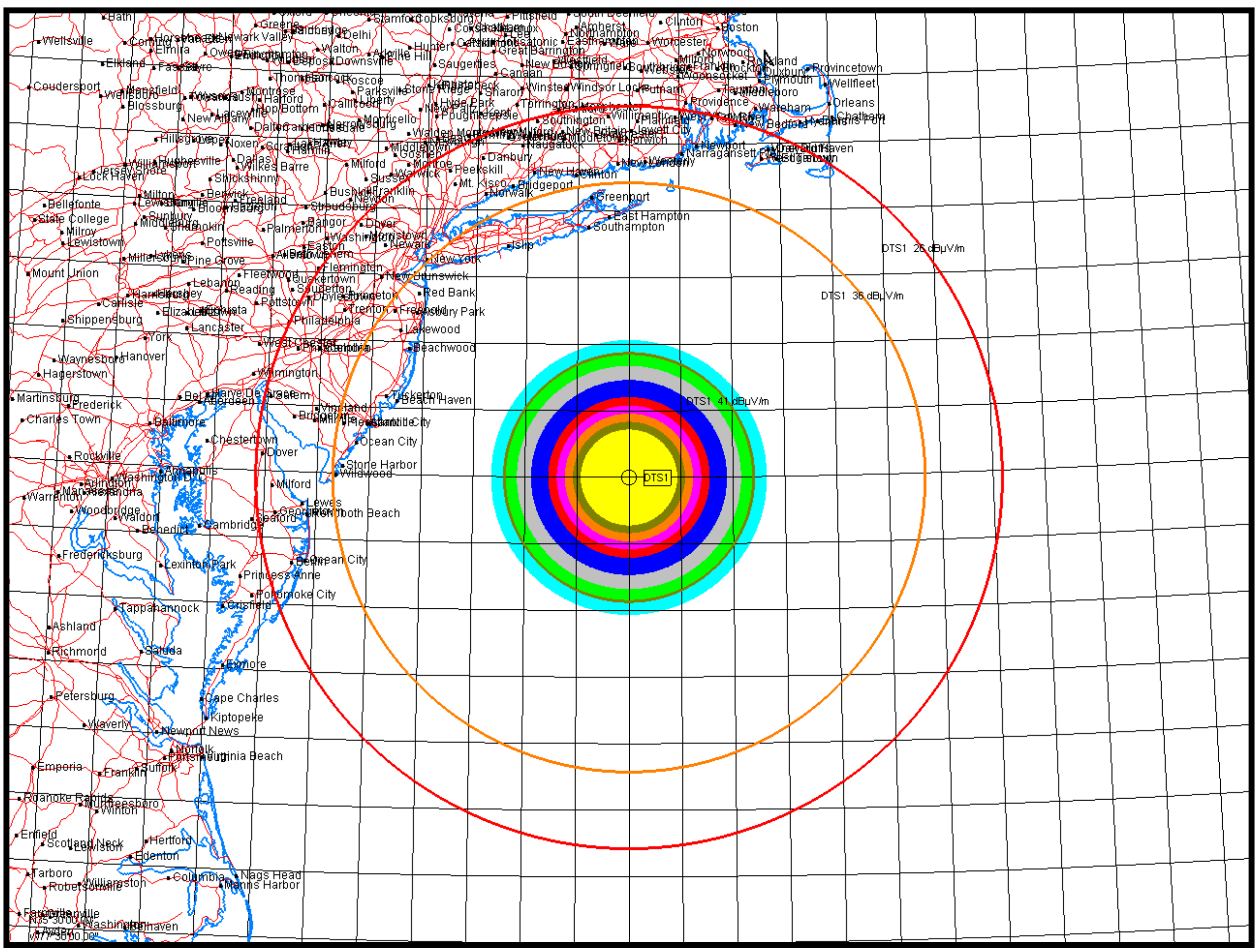

Figure 16 – Reference DTS Facility with Table of Distances Circle, 36 dBu and 26 dBu Contours

Figure 16 provides a reset of the discussion to the reference DTS facility and its contours so that they can serve as a starting point for examination of interference cases with respect to adjacent channel Class A stations. The Table of Distances circle provides the service area limit and protected service contour for the station (although other limits may be applicable in specific instances), and the 36 dBu and 26 dBu contours used in the co-channel discussion are retained for purposes of continuity.

In Figure 17, the location of another Class A station, labeled as "LPTV2" is identified. It is on a channel adjacent to that of the DTS network. As before, its location was determined arbitrarily on the coordinate grid to place it due east of the DTS reference facility and at a distance that makes demonstration of the interference considerations easy. As there is a 2-dB difference in the D/U ratios required for upper-adjacent and lower-adjacent interference protection, this discussion will be based on the upper-adjacent case, which has the lower level of permissible interference.

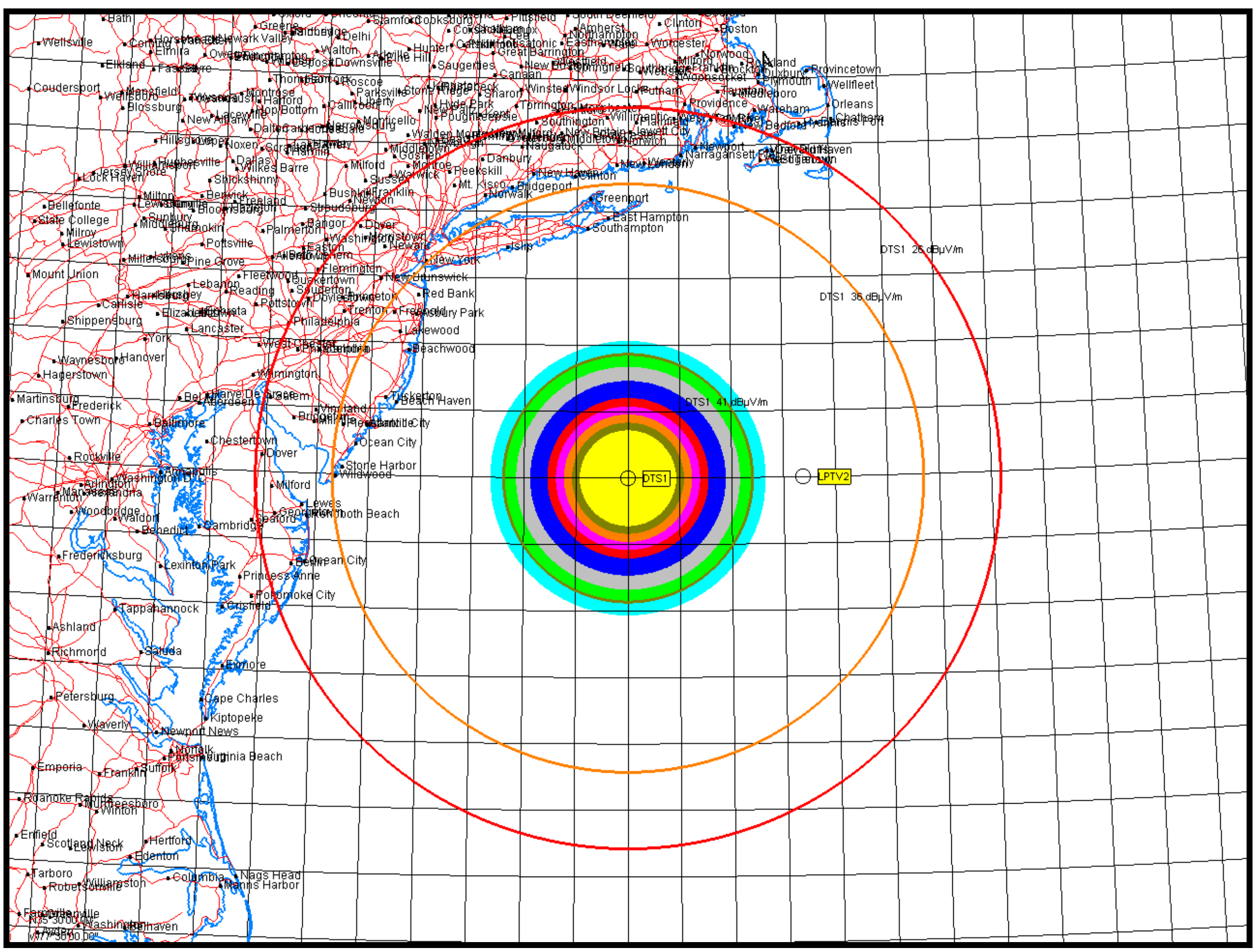

Figure 17 – DTS Network with Location of Class A Station on an Adjacent Channel

The D/U ratio between an upper adjacent interferer and a full service Digital Television (DTV) station is -26 dB, meaning that the interfering (Undesired) station can be 26 dB stronger than the Desired station. At the service area limit (or “protected” contour), the 41 dBu PNLC threshold will require an upper adjacent channel signal level of less than (41 + 26 =) 67 dBu to avoid interference at the contour. In Figure 18, it can be seen that the Class A station has been placed so that its orange 67 dBu contour just touches the olive Table of Distances circle (synonymous with the protected contour) of the DTS reference facility.

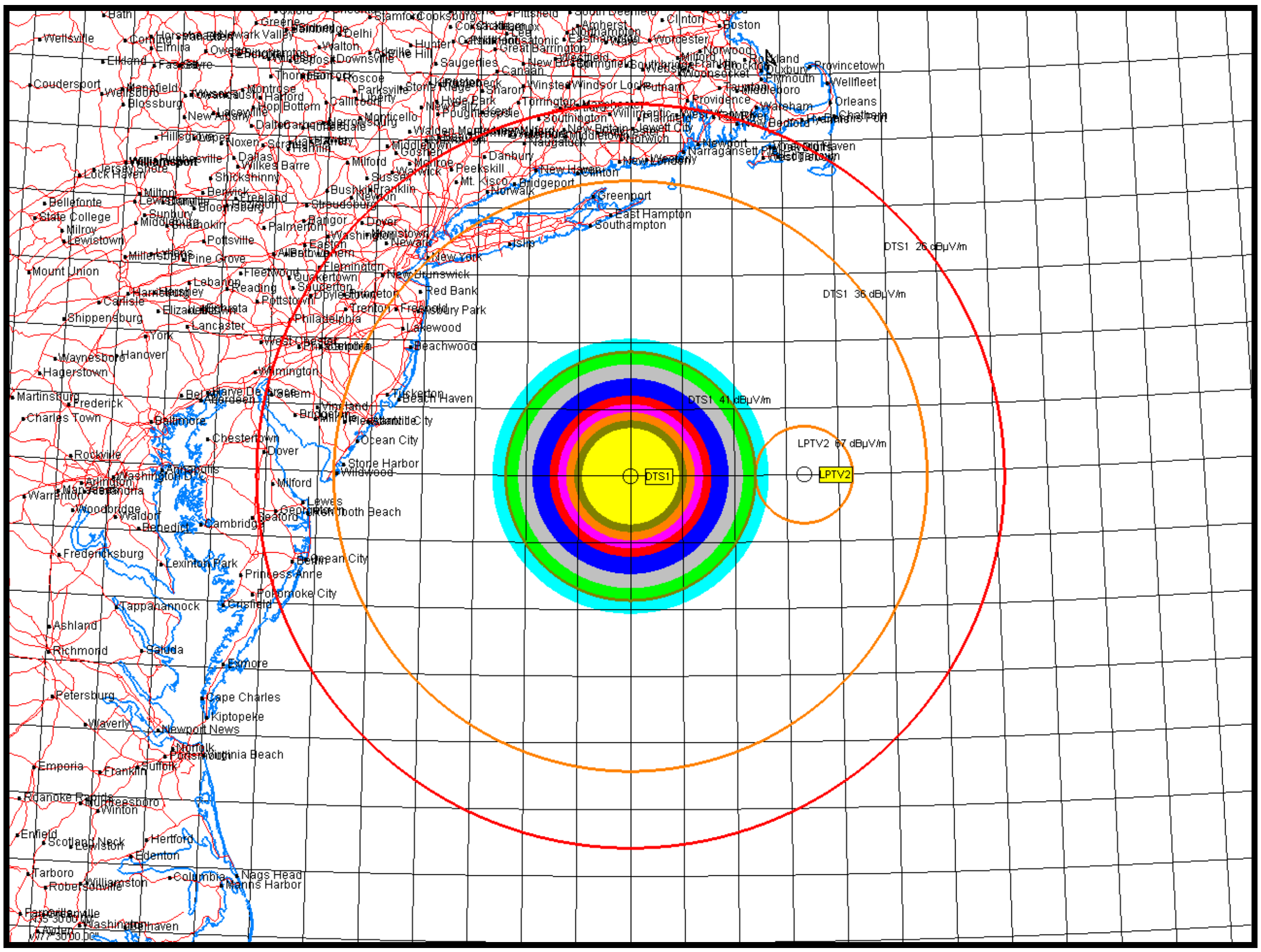

Figure 18 – DTS Reference Facility with Upper Adjacent Class A Station Interference Contour Just Touching

To protect the Class A station from adjacent channel interference (in the reverse case, on the lower adjacent channel), the station will be analyzed for protection at its 51 dBu protected contour from signals of (51 + 26 =) 77 dBu or greater (using the lower value also for upper adjacent channel protection, just to be conservative in the analysis). The results can be seen in Figure 19, in which the 77 dBu contour of the reference DTS1 facility is the light blue circle at the inside edge of the red (80 – 85 dBu) band surrounding the DTS1 transmitter. The location of the 77 dBu F(50:10) light blue circle at the 85-dBu F(50:90) point in the Longley-Rice analysis highlights differences in the results of the two propagation modeling methods.

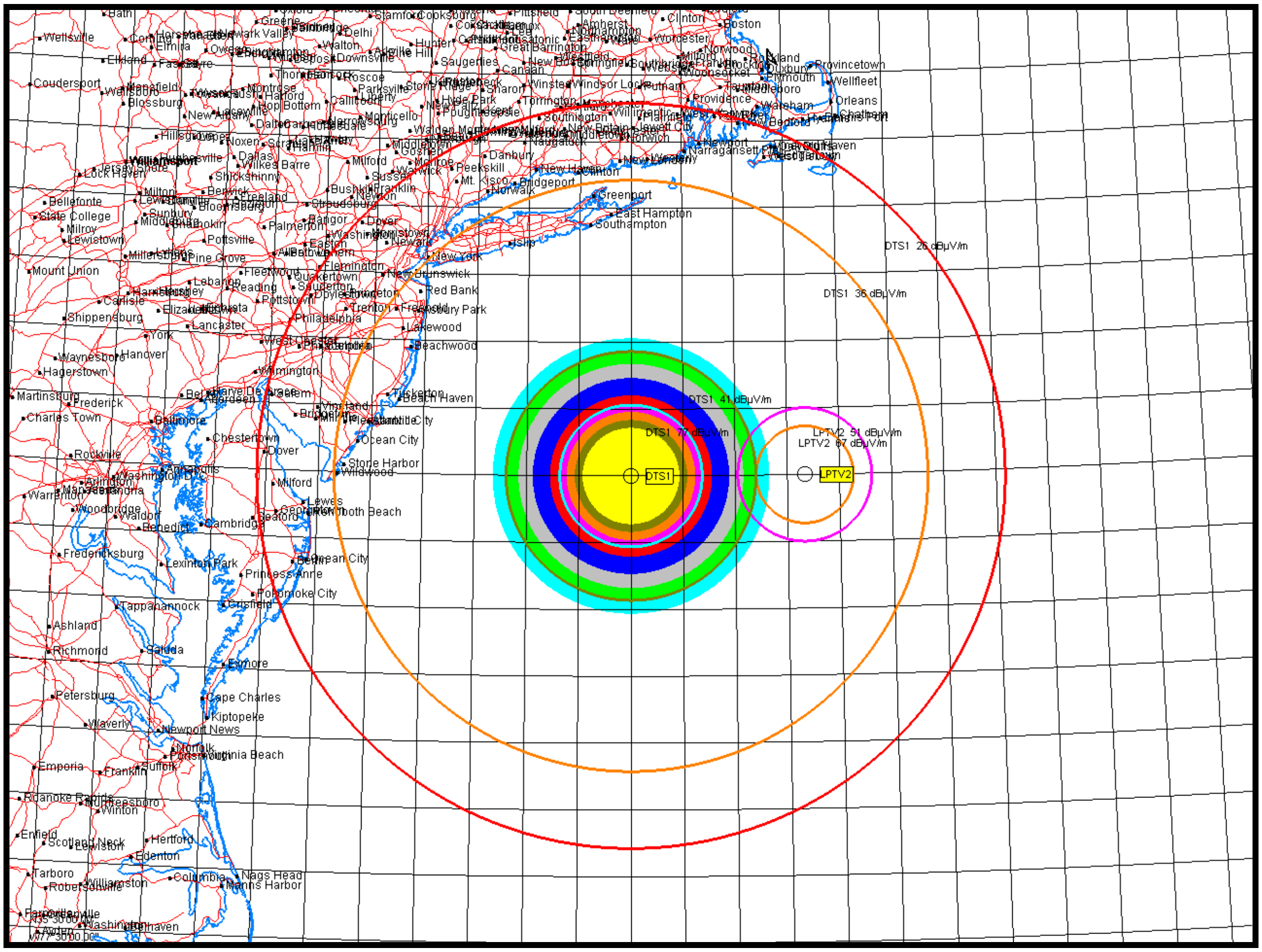

Figure 19 – DTS1 & Class A Stations with 77 dBu & 67 dBu Contours for Adjacent Channel Protection

In Figure 19, the bidirectional protection between the two stations is based on the orange 67 dBu F(50:10) contour of the Class A station just touching the Table of Distances circle (equivalent to the protected service contour) of DTS1 and the light blue 77 dBu F(50:10) contour of DTS1 being well-separated from the violet 51 dBu F(50:90) protected contour of the Class A station.

In Figure 20, the 100 kW DTS2 transmitter is added back into the picture. In this scenario, the important contours are the light blue 77 dBu F(50:10) contour around the DTS2 transmitter and the orange 67 dBu F(50:10) contour around the Class A transmitter (labeled “LPTV2a”), as well as the olive Table of Distances circle / protected contour of both the DTS1 transmitter and the

DTS network, and the violet 51 dBu F(50:90) protected contour of the Class A station. In this instance the Class A transmitter has been positioned so that its 51 dBu protected contour just touches the 77 dBu contour of the DTS2 transmitter, with the result that the 67 dBu contour of the Class A transmitter is reasonably well separated from the Table of Distances circle / protected contour of the DTS network. To reach this configuration, In Figure 20, the Class A transmitter is positioned slightly to the east of its location in Figure 19.

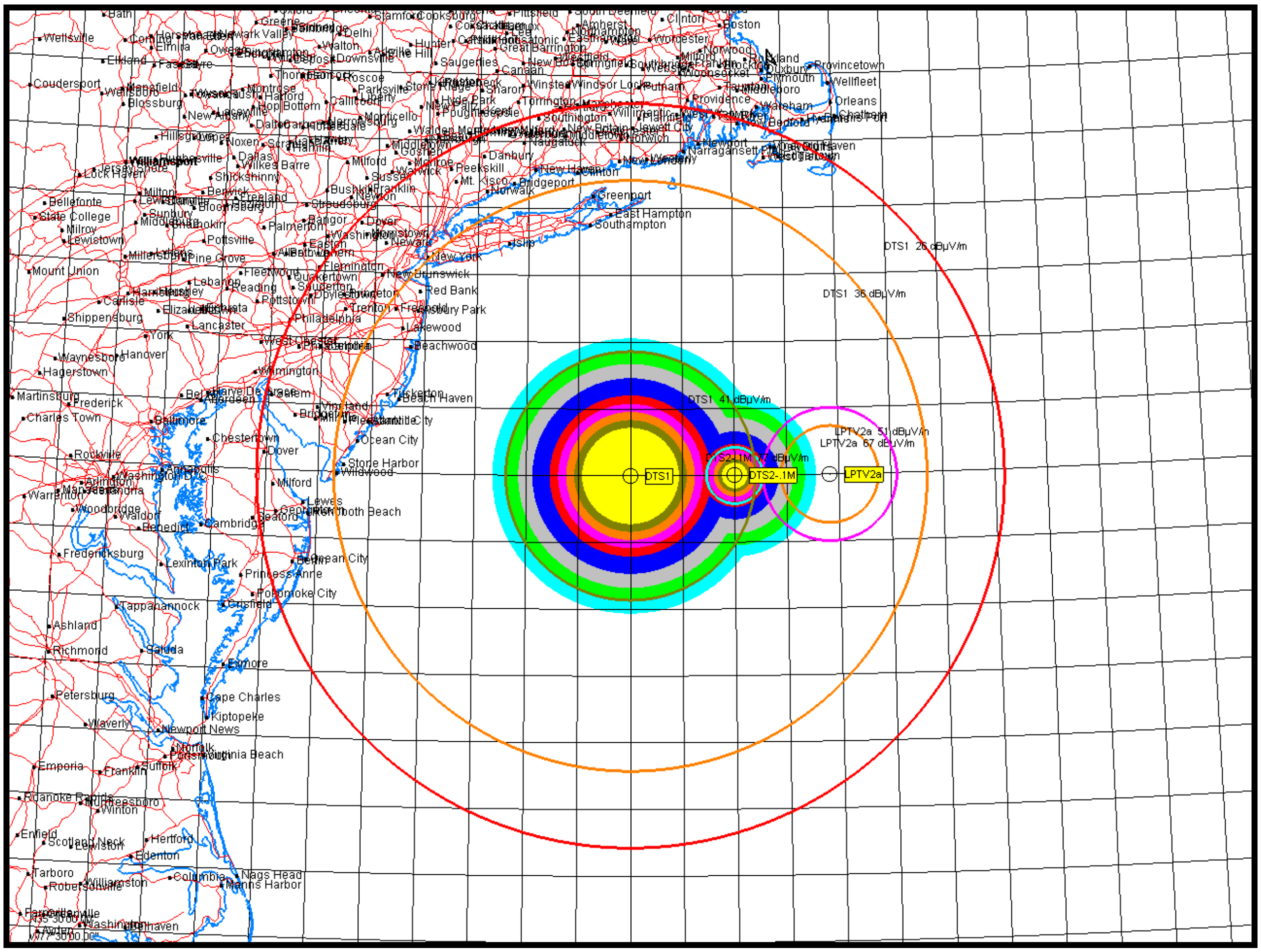

Figure 20 – DTS1, DTS2 & Class A Transmitters with 77 dBu & 67 dBu Contours for Adj. Chnl. Protection

In this discussion, it has been shown that it is possible to significantly increase the availability, spectrum efficiency, and performance of Distributed Transmission System networks with small modifications of the FCC rules and its TVStudy software. The fundamental change proposed is to require that the transmitters in a DTS network not exceed the 36 dBu UHF Interference Contour of the DTS Reference facility so that protection of co-channel Class A stations at their 51 dBu protected contours will be maintained. This would be in lieu of the current requirement that the PNLCs of all transmitters in a DTS network not exceed the PNLC of the hypothetical reference facility in the network, which requirement has been found through experience to be highly constraining in terms of network performance and spectrum efficiency, as well as very expensive to implement.

While the discussion has focused on the UHF case, where most DTS networks are likely to be located, similar relationships could be established for VHF stations and their respective threshold signal and interference levels. The objective of the proposed change is to make it practical and economical for broadcasters to construct and operate many more DTS networks than in the past so that they can take advantage of the capabilities of ATSC 3.0 to deliver signal data from the overlapping signals of multiple transmitters that can be so easily implemented with the technology of ATSC 3.0.

ATSC Documents to Be Referenced

In ¶62 of the NPRM, there is discussion of the possible need to adopt a synchronization standard in order to authorize an ATSC 3.0 SFN, with the tentative conclusion that no such adoption is necessary. When the DTS NPRM was under consideration, the same issue was raised, with the same tentative conclusion. As the originators of the technology that permitted synchronization of ATSC 1.0 transmitters and the owners of the intellectual property that resulted, we not only concurred in that decision but supported it. That remains the case with respect to ATSC 3.0 and synchronization of transmitters operating according to that standard suite.

There are many ways in which such synchronization can be obtained, and while the ATSC has developed an approach to transmitter synchronization that is being standardized to facilitate interoperation of equipment obtained from different manufacturers, there is no reason for the Commission to constrain the choices that broadcaster can make. More important is that the Commission adopts rules for operation of DTS networks, or SFNs, such as have been proposed, that assure that the networks can operate without uncontrollable internal interference within the networks.

With respect to the LG comment that “the standard that would enable an ATSC 3.0 SFN is ATSC A/322:2016 ‘Physical Layer Protocol’,” we disagree with respect to that being the case and with the necessity for its adoption by the FCC to enable use of SFNs with ATSC 3.0. While the fundamental Coded Orthogonal Frequency Division Multiplexing (COFDM) waveform used in the ATSC 3.0 Physical Layer and many other data processing aspects of the Physical Layer are described in A/322, that document is not the one that describes how to synchronize and manage multiple transmitters in a network. The document that does so is A/324 “Scheduler / Studio to Transmitter Link,” and as indicated above, we do not believe it to be appropriate for adoption by reference in the Commission’s rules for the reasons stated above.

Aggregation of Interfering Signal Levels

In the current DTS rules, in §73.626(f)(5), it says that an application must meet the condition that, “The ‘combined field strength’ of all the DTS transmitters in a network does not cause interference to another station in excess of the criteria specified in § 73.616, where the combined field strength level is determined by a ‘‘root-sum-square’’ calculation, in which the combined field strength level at a given location is equal to the square root of the sum of the squared field strengths from each transmitter in the DTS network at that location.”

While we participated in the discussion among members of the Association of Federal Communications Consulting Engineers (AFCCE) that prepared comments supporting such an approach, which had been suggested by an AFCCE member in comments on the DTS NPRM, we have not seen the possible implementation of that method until recently, when we found the following in Appendix C of the TVStudy Version 2.2 Instruction Manual:

> ***Root Sum Square***
>
> This is the square root of the power summation of all the wireless received field strength after receiver antenna discrimination in a single grid cell.

$$RSS = 20 * Log_{10}\left(\sum\left(10^{\left(\frac{dB\mu+G_r}{20}\right)}\right)^{2}\right)^{\frac{1}{2}} = 10 * Log_{10}\left(\sum 10^{\left(\frac{dB\mu+G_r}{10}\right)}\right)$$

We believe this implementation of the root sum square (RSS) function potentially to be incorrect. The reason for application of the RSS summation of the power levels from undesired transmitters is that it is extraordinarily unlikely that the waveforms of the multiple transmitters in a network will precisely align with one another in both symbol timing and RF phase in the field. Consequently, rather than a straightforward addition of power, an essentially statistical approach is needed due to the decorrelation of the signals caused by their different arrival times at any receiving location. Consequently, it is necessary to apply the RSS summation to the power contributions from the several transmitters in a network. As shown in the right-hand formulation of the function, what is being applied is a pure addition of power rather than an RSS summation of power. We believe that to be an incorrect result that will over-predict the signal power at any receiving location.

Since the math potentially used was only recently exposed and since the matter of ATSC 3.0 DTS networks, the approval of which depend upon this math, is now under consideration, we suggest that the correctness of the mathematical approach be evaluated and modified if necessary, as soon as possible, and certainly before DTS applications for ATSC 3.0 operations begin to come before the Commission.

Conclusion

In these comments, we have endeavored to respond meaningfully on the subject of Distributed Transmission Systems and changes in the rules that we believe are necessary if ATSC 3.0-based DTS networks are to be implemented successfully.. We believe the technology of distributed transmission can be an extremely valuable tool for many broadcasters in providing expanded DTV service to the public. With relatively few changes to its Rules and software, the Commission can and should develop a regime that improves on the current process for routine licensing of distributed transmission systems and that removes the constraints that prevent spectrum-efficient and economical implementation of such networks. Because distributed transmission systems will help accelerate the transition to ATSC 3.0 in a spectrally efficient manner, the Merrill Weiss Group LLC submits that the rule changes proposed herein and that eventually may be adopted by the FCC are decidedly in the public interest.

We also believe that it is unnecessary for the Commission to adopt by reference any documents in the ATSC 3.0 suite of standards beyond the A/321 standard. We further suggest that the mathematical analysis of the Root Sum Square (RSS) function currently described with respect to the TVStudy software be evaluated to assure that it is serving its intended purpose.

Respectfully submitted,

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